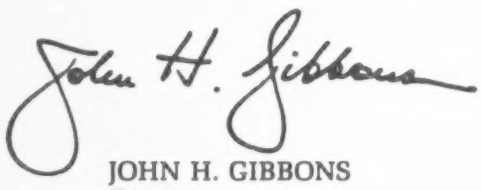
Foreword

Americans are very concerned about hazardous waste. Opinion polls consistently show that the public worries more about hazardous waste than about any other environmental issue.

OTA's first report on hazardous waste in 1983, *Technologies and Management Strategies for Hazardous Waste Control*, examined the environmental problems and high long-term costs of land disposal practices and the benefits of alternative waste treatment technologies. Congress made substantial use of that analysis in its 1984 amendments to the Resource Conservation and Recovery Act. In 1985 OTA's *Superfund Strategy* examined the U.S. program to clean up uncontrolled hazardous waste sites. The report shed new light on the scope of the problem and showed how permanently effective cleanup techniques based on waste treatment can replace leaving or redisposing Superfund wastes in the ground. The report assisted Congress in its deliberations on reauthorizing the Superfund program. Currently OTA is completing a study of Wastes in Marine Environments, including incineration in the open ocean.

Now Congress is turning its attention to preventing hazardous waste problems by cutting down on the generation of hazardous waste at its source. The following committees requested the OTA study on waste reduction: Senate Labor and Human Resources, House Energy and Commerce, House Science and Technology, and House Small Business. But while everyone agrees in a philosophical sense that waste reduction is good, there is confusion about definitions and methods and, thus, about what is feasible. *Serious Reduction of Hazardous Waste* examines what is meant by hazardous waste, waste reduction, and even waste reduction technology. The report explores the meaning and consequences of giving primacy to waste *reduction* over waste *management*. The range of policy options examined is intended to assist what surely will be an extensive policy debate—similar in extent and importance to the energy efficiency debates of the past 15 years.

A broad range of perspectives and a great deal of information on waste reduction were obtained from the advisory panel, several workshop groups, respondents to a survey, and many others who provided information and assistance. OTA thanks them for their time and cooperation. Their participation, however, does not necessarily represent endorsement of the contents of the report, for which OTA bears sole responsibility.



JOHN H. GIBBONS
Director

Serious Reduction of Hazardous Waste Advisory Panel

Frank L. Parker, *Chairman*
Vanderbilt University

Sandy Bihn
Administrator for the City of Oregon, Ohio

Lisa Bunin
Greenpeace

Joseph Chu
General Motors Corp.

Henry S. Cole
Clean Water Action Project/National Campaign Against Toxic Hazards

Peter S. Daley
Chemical Waste Management, Inc.

Dennis Drolet
Norchem, Inc.

Harry Fatkin
Polaroid Corp.

Ken Geiser
Tufts University

Phil D. Horelick
Allied Metal Finishing Corp.

Susan Johnnie
Hewlett Packard Corp.

James Lester
Colorado State University

Cindy McComas
Minnesota Technical Assistance Program

James Miller
Massachusetts Department of Environmental Management

Marian Mudar
New York State Environmental Facilities Corp.

M.L. (Mort) Mullins
Monsanto Corp.

James W. Patterson
Illinois Institute of Technology

David Roe
Environmental Defense Fund

David Sarokin
INFORM

Russell H. Susag
3M

NOTE: OTA appreciates and is grateful for the valuable assistance and thoughtful critiques provided by the advisory panel members. The panel does not, however, necessarily approve, disapprove, or endorse this report. OTA assumes full responsibility for the report and the accuracy of its contents.

OTA Project Staff—Serious Reduction of Hazardous Waste

Lionel S. Johns, *Assistant Director, OTA*
Energy, Materials, and International Security Division

Audrey Buyrn, *Manager*
Industry, Technology, and Employment Program

Joel S. Hirschhorn, *Project Director*

Kirsten Oldenburg, *Assistant Project Director*

Martha Finnemore, *Research Analyst*

Edna Thompson, *Administrative Assistant*

Joyce Wills, *Secretary*

Elinor Horwitz, *Editor*

Contractors

David A. Allen

Gary A. Davis

Hampshire Research Associates

Michael Modell

OTA Workshop: Large Business Perspectives on Hazardous Waste Reduction

Jerry Berger
Shell Oil

Elliott Berkihiser
The Boeing Co.

Dick Constable
Sun Co.

Gary Crouth
Alcoa

David Gordon
Dow Corning

Khristine L. Hall
IBM

Edward J. Hessler
The Upjohn Co.

Susan Johnnie
Hewlett Packard Corp.

Andy Lampert
Diamond Shamrock Chemical

Martin B. MacInnis
GTE Products Corp.

Jerry B. Martin
Dow Chemical

Nick Odom
Springs Industries, Inc.

E.E. Sale
Exxon Chemical Americas

Norman Sealander
Northrop Corp.

Thomas Sliva
General Electric

Donald Smith
Polaroid Corp.

Steve Song
General Motors Corp.

Anthony Spinola
U.S. Steel Corp.

Russell H. Susag
3M

OTA Workshop: Small and Medium-Sized Business Perspectives on Hazardous Waste Reduction

David Anzures
California Technical Plating
California

Peter Bohlmann
Nordic Ware
Minneapolis

Harry DeSoi
Pioneer Metal Finishing
New Jersey

Dennis Drolet
Norchem
Illinois

Rudolph C. Gabel
Sybron Corp.
New York

Robert Hall
ESAB North America, Inc.
Colorado

Richard C. Herring
The Gloucester Co.
Massachusetts

Paul Hoffman
Garden Way, Inc.
New York

Phil Horelick
Allied Metal Finishing
Maryland

Jim Hornburg
The Dexter Corp.
New York

John McInerny
Cambridge Plating
Massachusetts

George McRae
Stanadyne, Inc.
North Carolina

Cort G. Platt
Precious Metals Platers
Minnesota

Russell Smith
Salsbury Laboratories
Iowa

OTA Workshop: State Activities in Waste Reduction

William C. Arble
Pennsylvania Technical Assistance Program

Susan Boyle
New Jersey Hazardous Waste Commission

Robert M. Confer
New Jersey Department of Environmental Protection

Lee Dane
Massachusetts Department of Environmental Management

Frederick L. Doll
Illinois Hazardous Waste Research and Information Center

A.J. Englande
Tulane University
Louisiana

Joseph M. Flynn
Connecticut Department of Economic Development

Rebecca Fricke (consultant)
Tennessee Department of Economic & Community Development

Gary E. Hunt
North Carolina Pollution Prevention Pays Program

Bob Laughlin
Ontario Research Foundation
Canada

Linda Little
Governor's Waste Management Board
North Carolina

Kate Quigley Lynch
Connecticut Hazardous Waste Management Service

Tom Lynch
New York Department of Environmental Conservation

Suzanne Mager
Massachusetts Department of Environmental Quality Engineering

Cindy McComas
Minnesota Technical Assistance Program

George Miller
University of Louisville
Kentucky

Marian Mudar
New York Environmental Facilities Corp.

Ruth Neff
Tennessee Safe Growth Team

Roger N. Schecter
North Carolina Pollution Prevention Pays Program

William M. Sloan
Maryland Hazardous Waste Facilities Siting Board

Benjamin Smith
Tennessee Safe Growth Team

Jim Solyst
National Governor's Association

T. Michael Taimi
Kentucky Department for Environmental Protection

Clifton J. Van Guilder
New York Department of Environmental Conservation

Valerie Wickstrom
Kentucky Natural Resources & Environmental Protection Cabinet

Harry Williams
Indiana Department of Environmental Management

Tom Yates
Tennessee Division of Solid Waste Management

Serious Reduction of Hazardous Waste for Pollution Prevention and Industrial Efficiency

SUMMARY

Waste reduction is an economically sensible response to what many people see as a hazardous waste crisis. Several thousand pounds of hazardous waste are generated annually for every person in the Nation. Many thousands of people have lost their drinking water because of contamination by toxic waste. Across the country there are thousands of sites contaminated by hazardous waste that require billions of dollars for cleanup. An increasing number of lawsuits are being brought by people who claim to have suffered adverse health effects from living near toxic waste sites. Also the number of lawsuits being instituted by the government is mounting rapidly. These suits claim that certain waste generators have not complied with regulations and that generators who have used waste management facilities now on the Superfund list must pay for cleanups.

Waste reduction is critical to the prevention of future hazardous waste problems. By reducing the generation of waste, industry can use materials more efficiently and achieve more certain protection for health and the environment. At the same time, industry can lower waste management and regulatory compliance costs, liabilities, and risks.

Although there are many environmental and economic benefits to waste reduction, over 99 percent of Federal and State environmental spending is devoted to controlling pollution after waste is generated. Less than 1 percent is spent to reduce the generation of waste. The current level of national spending for pollution control is about $70 billion. Two-thirds of this is spent by industry. Since many hazardous substances are not yet regulated, annual expenditures will, in all likelihood, continue to increase.

OTA finds that reducing waste to prevent pollution from being generated at its source is now a practical way to complement this costly pollution control regulatory system. Because of sporadic and uneven enforcement, the current regulatory system weakens the incentive to reduce waste. Waste reduction, no matter how far it is taken, cannot eliminate all wastes, but it can help to lower costs for environmental protection as regulations continue to expand.

Current pollution control methods often do little more than move waste around. For example: air and water pollution control devices typically generate solid, hazardous waste that goes to landfills and too often

leaches from there into groundwater. Many hazardous wastes, such as most toxic air emissions, are not yet regulated, and regulatory standards for permissible emissions legally sanction the generation of some wastes. Thus, **OTA finds that establishing a comprehensive, multimedia approach to reducing wastes going into the air, land, and water is essential.**

OTA finds that there is no common definition of waste reduction; there are few or no data on the extent of industrial waste reduction; waste reduction is usually measured incorrectly; and the information that the government collects on waste generation is not useful. If waste reduction is defined to include waste treatment, companies will naturally pay more attention to treatment, which is a familiar activity, than to the reduction of waste. **Problems of definition and lack of information should be addressed and ongoing waste reduction efforts should be documented by government, even if decisions to reduce waste remain at the discretion of individual companies.**

Despite some claims to the contrary, industry has not taken advantage of all effective waste reduction opportunities that are available. Reducing waste involves more than buying a black box, reading the directions, and plugging it in. Even a simple step toward waste reduction can seem difficult to a company with few technical resources and no obvious place to go for guidance. Reducing waste in an industrial process requires intimate knowledge of all aspects of that specific produc-

Definitions Used in This Report

Waste Reduction:

In-plant practices that reduce, avoid, or eliminate the generation of hazardous waste so as to reduce risks to health and environment. Actions taken away from the waste generating activity, including waste recycling or treatment of wastes after they are generated, are not considered waste reduction. Also, an action that merely concentrates the hazardous content of a waste to reduce waste volume or dilutes it to reduce degree of hazard is not considered waste reduction. This definition is meant to be consistent with the goal of preventing the generation of waste at its source rather than controlling, treating, or managing waste after its generation.

Hazardous Waste:

All nonproduct hazardous outputs from an industrial operation into all environmental media, even though they may be within permitted or licensed limits. This is much broader than the legal definition of hazardous solid waste in the Resource Conservation and Recovery Act, its amendments, and subsequent regulations. Hazardous refers to harm to human health or the environment and is broader than the term "toxic." For example, wastes that are hazardous because of their corrosivity, flamability, explosiveness, or infectiousness are not normally considered toxic.

tion process, in contrast to waste treatment, which is essentially an add-on to the end of the process. There are also clear pressures to reduce waste tomorrow, rather than today. **The attention and resources given to required pollution control activities limit the amount of thought, time, and money that industry can devote to waste reduction.** Some U.S. companies, however, have verified the fact that waste reduction pays for itself relatively quickly, especially when compared to the time needed to comply with regulations, obtain regulatory permits, or site waste management facilities. Some companies are even beginning to sell new products and services that help others to reduce waste.

Waste reduction succeeds when it is part of the everyday consciousness of all workers and managers involved with production—where the waste reduction opportunities are—rather than when it is a job only of those responsible for complying with environmental regulations. A few people with end-of-pipe, pollution control jobs are not in a position to reduce waste; such efforts must involve upstream workers and facilities.

There are five distinct approaches that industry can take to reduce hazardous waste: 1) change the raw materials of production, 2) change production technology and equipment, 3) improve production operations and procedures, 4) recycle waste within the plant, and 5) redesign or reformulate end-products. Among the opportunities that exist for common processes and wastes are: 1) using mechanical techniques rather than toxic organic solvents to clean metal surfaces, 2) using water-based raw materials instead of materials based on organic solvents, and 3) changing plant practices to generate less hazardous wastewater.

So far government has not required waste reduction. **OTA finds that it would be extraordinarily difficult for government to set and enforce waste reduction standards for a myriad of industrial processes.** The impact on industry, particularly on troubled manufacturing sectors, could be substantial. Alternatively, the United States could move to an economically sensible environmental protection strategy based on *both pollution control* (waste management) *and pollution prevention* (waste reduction) with the Federal Government providing leadership and assistance in the following ways.

First, through policy development, education, and oversight, Congress could help industry and the Nation profit from seeing waste reduction not as some unique technology, but as a field ready for innovative engineering and management. These opportunities are embedded in every part of the industrial production system. There is no way to predetermine the amount of waste reduction that is possible; its technical and economic feasibility depend on the characteristics, circumstances, and goals of specific waste generators. Waste reduction depends on the ability of organizations to modernize, innovate, and cut costs, thereby increasing profits and reducing long-term liabilities. Thus waste reduction could be used as a measure of performance as energy efficiency and productivity often are.

Second, there are a number of possible legislative actions that could clarify the definition of waste reduction, spur better collection of information on waste reduction, and encourage waste generators to devote more attention to the subject. If the Federal public policy goal is rapid and comprehensive hazardous waste reduction, then a strategy based on government leadership and assistance rather than on prescriptive requirements is likely to be the most effective. For example, Congress could: 1) create an Office of Waste Reduction with an Assistant Administrator within EPA, 2) create a grants program to develop generic or widely transferable technical support for waste reduction, 3) through new comprehensive waste reduction legislation require detailed reporting by industry on past waste reduction actions and plans for future efforts, 4) reward and facilitate waste reduction by offering industry concessions from existing pollution control regulatory requirements, or 5) create and use independent State Waste Reduction Boards to implement programs. Setting a national waste reduction goal of perhaps 10 percent annually could help convert the long stated importance of waste reduction into a true priority and reduce annual environmental spending substantially, ultimately by billions of dollars.

BACKGROUND

Currently, American environmental protection efforts emphasize control and cleanup of pollution by hazardous substances *after* they are generated and no longer serve a productive function. Virtually all industries, whether high technology, smokestack, or small shops, generate hazardous waste. The cost of controlling that waste totals many billions of dollars annually. Usually, hazardous industrial wastes are not destroyed by pollution control methods. Rather, they are put into the land, water, or air where they disperse and migrate. The result is that **pollution control for one environmental medium can mean that waste is transferred to another medium.**

As the costs of administering environmental programs and the costs of compliance mount, the economic and environmental benefits of reducing the generation of hazardous waste at its source have become

Waste Reduction and National Policy

"The Congress hereby declares it to be the national policy of the United States that, wherever feasible, the generation of hazardous waste is to be reduced or eliminated as expeditiously as possible. Waste nevertheless generated should be treated, stored, or disposed of so as to minimize the present and future threat to human health and the environment."

From the *Resource Conservation and Recovery Act*, as amended by the U.S. Congress in November 1984. This policy statement is supported by *waste minimization* provisions also added to the act.

more compelling. But it is exactly these regulatory requirements and the costs of complying with them that both encourage *some* waste reduction and make it difficult for industry to give waste reduction the priority and resources it deserves for near-term wide-scale implementation. **Although current costs for pollution control serve as an indirect incentive for waste reduction, it is not certain that: 1) an incentive exists for all firms, or for the most appropriate people or departments within a company; 2) all or most waste generators have the technical and economic resources to respond to that incentive; 3) the incentive is consistently supported by congressional and regulatory actions; or 4) that waste reduction will be the response.**

In practice, waste reduction is all too frequently subordinated to pollution control, even though reducing waste can be the most effective way to prevent environmental risk. The domination of pollution control over waste reduction is not new; it has occurred over many years and it will not be reversed overnight.

Federal law *says* that waste reduction is the preferred anti-pollution method; but government *actions* often send a different—or ambiguous—message to waste generators.

Federal and State actions, however, are not the sole determinants of how much waste is reduced. Frequently, inadequate information makes it difficult for waste generators to assess the benefits of a one-time, near-term investment for waste reduction versus *repeated* spending and ongoing liabilities over the long term for waste management. Pollution control measures are more familiar and thus more certain. Uncertainty also arises because waste reduction, as a measure of materials productivity, is subordinated to other measures of the efficiency of industrial operations, such as labor productivity and energy consumption.

As a result, waste reduction, which saves money for industry and protects the environment, is being implemented in an uneven and largely undocumented fashion. Assessing the economics of waste reduction poses problems. For some people a major focus on waste reduction raises concerns that it might, through the costs of implementation, contribute to what is called the "deindustrialization" of America. However, **those who have implemented waste reduction effectively generally see it as a way to improve profitability and competitiveness.** If waste reduction were to be carefully promoted and become more widespread—and virtually everyone believes this is possible, environmental and economic benefits would increase. Statistical documentation of the amount of waste reduction that has already occurred nationwide and a summary of its results would almost certainly remove the uncertainty that some representatives of industry and government have about the near-term feasibility of waste reduction.

OBJECTIVES OF THIS STUDY

The purpose of this study is to provide Congress with a concise base of information and analysis to assist it in ensuring implementation of

its declared national policy of reducing the generation of hazardous waste. More specifically, OTA defined the following study objectives.

1. *To explore the context for concern about waste reduction.* What is the significance of reducing the generation of all hazardous industrial waste rather than only those regulated as solid, hazardous waste under the Resource Conservation and Recovery Act (RCRA)? Why is waste reduction important? An initial task in this exploration was to adopt precise definitions of "hazardous waste" and "waste reduction."
2. *To examine the technological nature of waste reduction and the extent to which waste reduction has been and is likely to be implemented by industry.* To what extent is technology itself rather than information and resources a barrier to waste reduction? In what ways are waste reduction decisions dependent on the unique circumstances of a specific company or industry? Can the amount of feasible waste reduction be estimated? How much can research increase the feasible amount of waste reduction? (Note that only the policy aspects of this report deal solely with industrial waste generation, but all other discussions apply to nonindustrial waste reduction as well.)
3. *To analyze Federal programs that directly or indirectly affect industrial waste reduction.* Is the Federal Government playing a significant positive or negative role in assuring that waste reduction becomes more commonly adopted by American industry?
4. *To examine State programs that have been established to reduce industrial waste.* What is the extent and effect of State programs? Do State programs remove the need for Federal initiatives?
5. *To define and analyze a broad range of policy options that might help the Nation implement current national waste reduction policy without causing harm to American industry.* Is there a need for Federal initiatives and, if so, what are they? What are the advantages and disadvantages of implementing waste reduction?

PREVENTION AND CONTROL OF POLLUTION: THE PRIMACY OF WASTE REDUCTION

The national debate on the environment is beginning to move away from traditional discussions about how to make pollution control regulations effective. A more fundamental question is now being posed: *How can pollution prevention be used to complement pollution control?* Some years ago, Dr. Joseph T. Ling of 3M articulated the case for pollution prevention:

> Pollution controls solve no problem; they only alter the problem, shifting it from one form to another, contrary to this immutable law of nature: the form of matter may be changed, but matter does not disappear . . . [I]t is apparent that conventional controls, at some point, create more pollution than they remove and consume resources out of proportion to the benefits derived . . . What emerges is an environmental paradox. It takes resources to remove pollution; pollution removal generates residue; it takes

more resources to dispose of this residue and disposal of residue also produces pollution.[1]

More recently, 3M summed up its unrelenting pollution prevention efforts since 1975:

> The combined total of almost 1,900 projects has resulted in eliminating *annually* the discharge of almost 110,000 tons of air pollutants, over 13,000 tons of water pollutants, and over 260,000 tons of sludge of which over 18,000 tons are hazardous—along with the prevention of approximately 1.6 billion gallons of wastewater. Cost savings to 3M total more than $292 million. These costs are for pollution control facilities that did not have to be built; for reduced pollution control operating costs; for reduced manufacturing costs; and for retained sales of products that might have been taken off the market as environmentally unacceptable.[2]

Reduction—applied to a broad universe of emissions, discharges, and wastes—is the best means of achieving pollution prevention. However, developing a *complementary* environmental protection strategy, based on waste reduction, represents a major shift in thinking. Because we now have an entrenched pollution control culture, this shift would be a substantial challenge for industry and government. **But no matter how strongly waste reduction is advocated, pollution control regulations will always be needed for wastes that cannot be or have not yet been reduced.**

The traditional emphasis on pollution control and the prevalent viewpoint that substantial waste reduction is a long-term goal, not a realizable short-term strategy, constrain the consideration of alternatives by waste generators. (Paradoxically, the claim is also heard that all waste reducing measures that can be taken *have* been taken; i.e., that waste reduction is a used-up strategy.) One inhibiting factor is concern about risking product quality by tinkering with or changing processes solely for the purpose of reducing waste.

For companies and industries that are expanding production, waste reduction is an obvious way to offset the economic and environmental costs of managing increasing amounts of wastes. Waste reduction also addresses concerns about the economic inefficiency of increasing pollution control regulations; that is, spending more and more for smaller increments in environmental protection. Whatever their environmental benefits, experience shows that the development and implementation of pollution control regulations takes considerable effort, time, and money on the part of industry and government.

Figure 1 illustrates how steadily increasing environmental regulations have been paralleled by a growth in environmental spending by the Nation. There are many factors that determine the extent of national spending to protect the environment, including how much waste is generated, exactly what the regulations call for, and how these regulations

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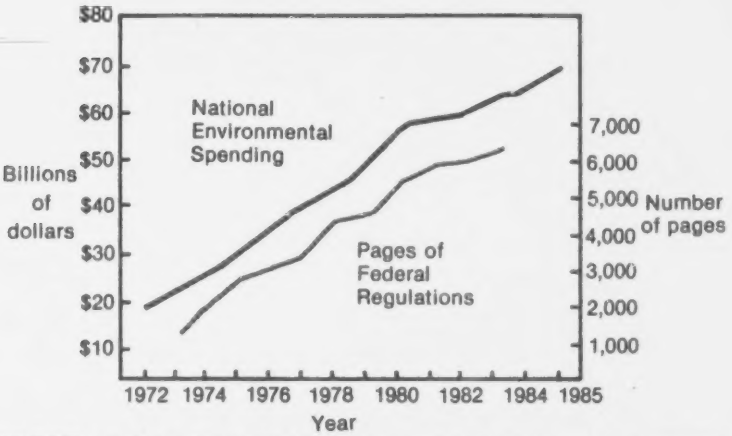
[1]Michael G. Royston, *Pollution Prevention Pays* (New York: Pergamon Press, 1979), p. xi. For a full articulation of the pollution prevention strategy, this book is considered the seminal work.

[2]M.D. Koenigsberger, 3M, paper presented at *Governor's Conference on Pollution Prevention Pays*, Nashville, TN, March 1986.

Figure 1.—Current Regulations: An Economic Incentive for Waste Reduction



SOURCES: L.B. Cahill, *The Weston Way*, Winter/Spring 1986 p. 26; and U.S. Department of Commerce and Management Information Services, 1985.

are enforced. But it is also apparent that over the past 14 years the simple size of the body of Federal regulations has been a fairly reliable proxy for the many substantive factors that determine spending. Over that period spending has been about $10 million for every page of Federal environmental statute and regulation. In 1985 $70 billion was spent nationally and there were 7,000 pages of Federal environmental statutes and regulations. **Two solutions present themselves for reducing national spending on the environment: government can change regulations—for example, by redefining hazardous waste, or by cutting regulations and/or limiting their enforcement—or generators can reduce wastes.** The latter approach is clearly the most desirable; waste reduction has already been demonstrated to have the capability—for some waste generators—of turning the spending curve down as regulations continue to increase.

But decreasing environmental spending nationwide through waste reduction can occur only if Federal statutes and regulations were to unequivocally establish the primacy of waste reduction (that is, of pollution prevention) over waste management. From the generator's perspective, waste reduction is an alternative that reduces the costs of regulatory compliance and that reduces the potential for enormous costs of later litigation. From the government's viewpoint, waste reduction does not sacrifice the integrity or environmental protection goals of pollution control regulations. **Asserting the primacy and economic importance of waste reduction does not necessarily mean that government must then prescribe and regulate the amount of waste reduction generators must accomplish. Nor does it imply that waste reduction can ever eliminate all wastes or the need for all pollution control regulations.** The meaning, case for, and implications of the primacy of waste reduction are discussed below.

What Is Waste Reduction?

The term *waste reduction* means different things to different people. Arriving at a definition of waste reduction is not a trivial pursuit. One study of waste reduction pointed out that the "difficulties and differences in definition . . . themselves constitute one of the factors affecting industry's decisions about the generation of hazardous waste."[3] **The definition of waste reduction also affects the design, implementation, and effectiveness of government actions.**

Box A summarizes the problems that arise from several characteristics of commonly used definitions of waste reduction and similar terms. The most serious problem is that any definition that includes waste management, including waste treatment and recycling away from the production site, will probably divert attention away from the goal of waste reduction. **The broadly accepted goal of minimizing the amount of hazardous waste put into the land should not obscure the even more fundamental goal of reducing the generation of hazardous waste.**

A number of definitions of waste reduction used by States and in studies include all waste recycling or waste treatment or both. For example, it is widely assumed that Federal statutes and regulations use the term *waste minimization* to include, along with waste reduction, preferred waste management activities that reduce the amount of waste to be land disposed. Thus, the Federal statute and regulations that allow generators to use their own definition also allow them to comply by improving waste management; there is no clear message that waste reduction is preferred, or that it should be considered first. **If waste reduction does indeed have primacy, then it must be defined and used in a way that allows no misunderstanding of what either waste reduction or primacy means.** Otherwise, better waste management could easily sap resources that might go to waste reduction. **Preferred waste management measures can and should stand on their own merits, rather than being considered a part of waste reduction.**

OTA has adopted a definition that addresses these shortcomings and is technically sound, consistent with the current congressional statement of national policy, and useful for discussing policy options. *It also reflects the importance for public policy development of defining waste reduction in a way that is consistent with the concept of pollution prevention.* OTA's definition is:

> **Waste reduction refers to in-plant practices that reduce, avoid, or eliminate the generation of hazardous waste so as to reduce risks to health and environment.**

The focus, therefore, is on what occurs at the source of generation. The goal of waste reduction is to alter current practice and to design future industrial processes and operations in a way that will reduce the degree of hazard of waste and the amount to be managed, controlled,

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[3]National Research Council, *Reducing Hazardous Waste Generation* (Washington, DC: National Academy Press, 1985), p. 9.

Box A.—Problems With Definitions of Waste Reduction and Similar Terms

Problem #1

Several terms currently are used to describe preferred methods of dealing with hazardous waste. These terms include:

waste reduction
waste minimization
waste abatement
source reduction
waste prevention
waste avoidance
waste elimination

No standard definitions exist for any of these terms. Each is defined differently by each user.

Problem #2

Definitions include pollution control activities as well as pollution prevention activities. Among these are:

- **out-of-process recycling;**
- **offsite recycling;**
- **onsite or offsite treatment, such as incineration; and**
- **weight or volume reduction with a corresponding increase in concentration of hazardous content.**

The distinction between preventing waste from being generated and controlling waste after it is generated is blurred when pollution control actions are included in the definition of waste reduction and similar terms. Consequently:

- **the primacy of pollution prevention is eroded,**
- **generators are not encouraged to consider pollution preventing activities because pollution control options are given equal standing,**
- **risks to health and the environment from transport and handling of waste are ignored, and**
- **measurements of reduction of waste generation are obscured by including the results of pollution control.**

Problem #3

Definitions do not apply to all hazardous wastes. Most definitions apply reduction only to some combination of the following:

- **RCRA-regulated wastes (wastes regulated under Clean Water and Clean Air are excluded);**
- **toxic wastes (hazardous, but nontoxic wastes are excluded); or**
- **regulated wastes (hazardous, nonregulated wastes such as most toxic air emissions are excluded).**

and regulated. A recent study concluded: "[i]n-plant options are probably the most effective and economical means of managing hazardous wastes."[4]

[4]Michael R. Overcash, *Techniques for Industrial Pollution Prevention* (Chelsea, MI: Lewis Publishers, Inc., 1986), p. 2.

The OTA definition addresses "what," "where," and "by whom" questions without specifying "how" waste reduction is to be carried out. An important consequence of this definition is that **various means of reducing waste, which are applied *after* the waste is generated outside of the location where waste is generated, are characterized as a form of waste *management*.**

Some difficulties in interpretation still occur, particularly in relation to waste recycling. **When recycling is environmentally acceptable and is an integral part of the waste generating industrial process or operation OTA considers it waste reduction.** An example is a closed-loop application which returns (potential) waste as it is generated for reuse within the process. To the extent that in-process recycling prevents transfer of hazardous material into the environment, it is waste reduction.

But recycling is *not* considered waste reduction if waste exits a process, exists as a separate entity, undergoes significant handling, and is transported from the waste generating location to another production site (perhaps a part of a large plant) for reuse, or to an offsite commercial recycling facility or waste exchange. This distinction does not mean that such waste *management* is unacceptable, unreasonable, or improper. On the contrary, as will be discussed in detail later, offsite recycling is a preferred waste management alternative. There can be valid reasons why such a waste management method is technically or economically justified for a specific industrial operation, such as for many generators of small quantities of hazardous waste.

But even recycling facilities pose risks. RCRA regulation of such facilities are to some extent a disincentive for recycling. This issue has received considerable attention. The distinction made here between in-process recycling that is a part of the waste generating activity and all other types of recycling may be a practical way to resolve that issue. If in-process recycling were regulated, that would indeed serve as a disincentive for its use; current RCRA regulations may or may not cover in-process recycling depending on how they are interpreted (see ch. 5 of the full report).

What Is Hazardous Waste?

Although toxic wastes are of major concern today, there is no reason why the concept of waste reduction must be restricted to toxics. OTA's definition of hazardous waste in this report is:

> **Hazardous waste refers to all nonproduct hazardous outputs from an industrial operation into all environmental media, even though they may be within permitted or licensed limits.**

This definition is much broader than that of hazardous waste under RCRA and is also more inclusive than the term *hazardous substances*, as used in the Federal Superfund program. Thus, this report covers a broad universe of hazardous substances and pollutants (toxic and con-

ventional) that industry generates, discharges, and emits routinely or accidentally.[5] **It is OTA's position that all hazardous wastes are amenable to waste reduction although the exact circumstances of a generator may not support reducing a particular waste. No technical case can be made for the notion that some wastes can be reduced and others cannot.**

Current environmental statutes, programs, and regulations may not cover all hazardous waste. Many wastes are covered by only some of the current regulations that separately control or manage disposal practices for the land, air, and water. For instance, RCRA hazardous wastes include toxic, ignitable, corrosive, and reactive substances. The Clean Air Act serves as the basis for regulating both criteria pollutants (such as ozone, particulates, sulfur oxides, carbon monoxide, nitrogen oxides, and lead) and hazardous air pollutants (often referred to as air toxics). Discharges into the Nation's waters are covered by the Clean Water Act and controlled by regulating both conventional (biochemical oxygen demand, fecal coliform, total suspended solids, oil/grease, and pH) and toxic or priority pollutants. (The various statutory and regulatory definitions of the preceding terms are given in chapter 5 of the full report.)

OTA has concluded that a comprehensive, multimedia (air, water, land) definition for hazardous waste is necessary. The two chief reasons for this conclusion are: 1) to avoid creating opportunities for shifting waste from one environmental medium to another possibly unregulated or less regulated medium, such as has happened for some wastes that are land disposed rather than being discharged into waterways; and 2) to include wastes that are not currently regulated, such as most toxic air emissions. If the term *hazardous waste* is defined or applied narrowly, waste reduction measures can be ineffective.[6] The situation regarding trichloroethylene (box B) is a vivid, but not necessarily typical, example of a widely used product almost all of which emerges from industrial processes as an unregulated hazardous waste. If only a RCRA definition is given to hazardous waste, nearly 90 percent of trichloroethylene waste that goes into the air and water will not be covered. A very different example is cadmium waste. In this instance 80 percent of the waste is land disposed and regulated under RCRA, 12 percent is emitted into the air, and 8 percent goes into surface water.[7]

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[5]With regard to the concept of "hazardous," the following definition of a hazardous material adopted by the California Department of Health Services is useful: a substance or combination of substances which, because of its quantity, concentration, or physical, chemical, or infectious characteristics, may either: 1) cause, or significantly contribute to an increase in mortality or an increase in serious irreversible, or incapacitating reversible, illness; or 2) pose a substantial present or potential hazard to human health or environment when improperly treated, stored, transported or disposed of or otherwise managed.

[6]It is, of course, better to have some waste reduction than none. Yet when reduction is limited, important and environmentally threatening wastes may receive no attention. For example, Du Pont, which has initiated a major waste reduction program and has already achieved considerable success, does not include air emissions and wastewaters discharged through permitted outfalls; and non-RCRA wastes are not always included. [*Waste Reduction: The Ongoing Saga*, proceedings of a Tufts University Center for Environmental Management conference, Woods Hole, MA, June 1986.]

[7]U.S. Environmental Protection Agency, "Cadmium Contamination of the Environment: An Assessment of Nationwide Risk," February 1985.

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Box B.—Waste Generation From Production and Use of Trichloroethylene

Type of Material.—Trichloroethylene (TCE) is a volatile halogenated organic chemical used widely as a solvent. It is known to be toxic to the liver and nervous system and is now considered a probable human carcinogen.

Production.—U.S. production in 1983 was 65,700 metric tons. Only about 100 tons (0.2 percent) were emitted to the atmosphere during production and only another 39 metric tons during distribution. Production has been decreasing since it peaked at 277,000 metric tons in 1970. This has been occurring, in part, because of the substitution of other solvents, such as methyl chloroform and perchloroethylene, which themselves may pose hazards.

Uses and Waste Generation.—*About 90 percent of TCE used becomes a hazardous waste.* In 1983, 85 percent (56,000 metric tons) of all TCE produced was used as a solvent for cleaning and degreasing operations in many thousands of plants nationwide; 52,600 metric tons (94 percent) were emitted to the atmosphere. The second major use is in manufacture of polyvinylchloride (PVC); of this 8,500 metric tons about 130 metric tons (2 percent) are emitted to the atmosphere, the balance being consumed in the process reaction. Essentially all of remaining usage is assumed to be emitted to the atmosphere.

Waste Management Media Transfer.—Release of TCE into the environment (for 1978) has been estimated to be: 86 percent into the air, 12 percent into the land, and 2 percent into water. Much of what goes into the land and water can volatilize. An EPA analysis of industrial wastes discharged to publicly owned treatment works indicates that two-thirds of the input TCE (1,729 metric tons) is emitted into the air, 5 percent goes into surface water, 6 percent goes into sludge, and 23 percent is destroyed by biodegradation. Other than by natural degradation in the atmosphere, only about 0.7 percent of TCE waste is destroyed through treatment.

Presence at Superfund Sites.—Found by EPA to be the most frequently occurring substance overall (at 179 of 546 sites); number one for groundwater, third in surface water, and fifth in the air.

Regulation.—Although TCE as a waste exists predominantly as an air pollutant, EPA has only recently given notice of intent to list TCE as a hazardous air pollutant under Section 112 of the Clean Air Act (March 1986). TCE is regulated under RCRA as a solid, hazardous waste and is considered a hazardous substance under CERCLA (Superfund). As one of 126 priority toxic pollutants, TCE is also regulated under the Clean Water Act. Under the Safe Drinking Water Act, the Recommended Maximum Contaminant Level is zero in drinking water, and the Maximum Contaminant Level (enforceable standard) in drinking water is 0.005 mg/l. Under the Occupational Safety and Health Act, the 8-hour time weighted average exposure limit for a 40-hour week is 100 ppm, with an acceptable ceiling concentration of 200 ppm.

SOURCES: U.S. Environmental Protection Agency, "Survey of Trichloroethylene Emission Sources," July, 1985; U.S. Environmental Protection Agency, "Intermedia Priority Pollutant Guidance Document: Chlorinated Solvents," October 1984; U.S. Environmental Protection Agency, *Report to Congress on the Discharge of Hazardous Wastes to Publicly Owned Treatment Works*, February 1986.

Public and Private Roles

Historically, Federal policy has not *directly* promoted waste reduction as a method of environmental protection. The extent of State government efforts on waste reduction dwarfs Federal ones, even though, as will be discussed later, State efforts are also limited. However, Federal regulatory programs have provided some indirect economic incentives for waste reduction by increasing the cost of compliance with waste management regulations as well as increasing insurance costs and costs of cleaning up toxic waste sites. These indirect incentives have been particularly effective for *some* waste generators and for *some* wastes.

However, this effectiveness is weakened by poor and uneven enforcement of regulatory programs and by markedly different levels of regulation for specific wastes. **By relying solely on indirect incentives, the government presumes that a company is motivated to implement waste reduction techniques and that it has the technical and economic resources to do so.**

In the private sector, successful waste reduction efforts have generally been a consequence of attempts to increase the efficiency of industrial operations. **Waste represents inefficiency and it is indisputable that industry reduces some hazardous waste, since to reduce waste is to conserve materials that may be scarce, strategic, or expensive.** Most commonly, waste reduction has been a byproduct, not a focus, of altered industrial processes since waste management costs have rarely been so high as to suggest alternatives. At some point, continued efforts to improve the yield of industrial processes by maximizing product output relative to input of raw materials will not appear economically attractive because the amounts of product increases will be small.

Yet reducing waste generation may, in its own right, be significant today because of rising waste management costs, anticipated long-term liabilities, and environmental risks. But these may not be factored into decisions made by generators, especially if the focus is on product yield rather than on waste reduction. Accounting methods that do not assign the full short- and long-term costs of waste generation to production profit centers can further obscure the economic considerations that should be available to decisionmakers if wise choices are to be made. **OTA believes that although some success has been achieved for waste reduction by American industry, more can be accomplished and that waste reduction represents a primary, economically viable means of hazardous waste control** (see box C).

Waste reduction has traditionally been the prerogative of industry and even now industry and government generally see it as a *voluntary* practice. However, consider the following policy statement that was added to RCRA in 1984:

> The Congress hereby declares it to be the national policy of the United States that, wherever feasible, the generation of hazardous waste is to be reduced or eliminated as expeditiously as possible.

Box C.—Ways Companies Can Promote Waste Reduction

- **Conduct a waste reduction audit** to provide information about: 1) types, amounts, and level of hazard of wastes generated; 2) sources of those wastes within the production operation; and 3) feasible reduction techniques for those wastes.
- **Revise accounting methods** so that both short- and long-term costs of managing wastes, *including* liabilities, are charged to the departments and individuals responsible for the processes and operations that generate the waste.
- **Involve all employees** in waste reduction planning and implementation. Waste reduction must be seen as the responsibility of all workers and managers involved in production, rather than just the responsibility of those who deal with pollution control and compliance.
- **Motivate employees** and focus attention on waste reduction by setting goals and rewarding employees' suggestions that lead to successful waste reduction. Special education and training can help all types of employees identify waste reduction opportunities at all levels of operation and production.
- **Transfer knowledge throughout the company** so that waste reducing techniques implemented in one part of the company can benefit all divisions and plants. This is particularly important in large companies. Newsletters and company meetings can be helpful tools for disseminating information about waste reduction opportunities.
- **Seek technical assistance** from outside sources. This may be particularly useful for smaller companies with limited technical resources. Sources of outside assistance include State programs, universities, and professional consultants.

The second sentence of this statement concludes that:

> Waste nevertheless generated should be treated, stored, or disposed of so as to minimize the present and future threat to human health and the environment.

This policy statement implies that waste reduction has primacy over waste management. The lack of a direct mention of *economic* feasibility or practicality makes the statement especially strong. But policy is not clear, because the RCRA statutory term *waste minimization* is interpreted by many people to give equal footing to preferred waste management. It is not entirely clear whether this government policy states that a decision to use a preferred form of waste management should occur only **after** a thorough exploration of the feasibility of waste reduction.

A summary of the problems associated with those 1984 RCRA Amendments that deal with waste reduction and minimization, the regulations based on these amendments, and their implementation by EPA and the

States is given in table 1. For the most part, the 1984 congressional action does not alter the voluntary character of industrial waste reduction. Its significance is that it has raised the level of importance of waste reduction in the eyes of industry decisionmakers. **A major policy issue facing the Federal Government is whether it should become *directly* involved in stimulating or even requiring waste reduction.**

It is important to be aware, however, of ways in which government actions could be harmful to U.S. industry. For example, **some types of mandatory waste reduction regulations with enforced penalties for noncompliance could harm international competitiveness for some industries and products because they are too inflexible, are inattentive to site-specific constraints, or ignore capital investment needs.** High costs for implementation not born by competitors and standards applied equally across U.S. industry could have grave consequences for troubled manufacturing sectors.

On the positive side, over 80 percent of 99 small, medium, and large companies surveyed by OTA[a] believe that employment would either increase or not be affected by stepped-up but not necessarily mandated waste reduction efforts. Increasing waste reduction also will help reduce the presence of toxic chemicals everywhere, an environmental benefit that is often cited. Waste reduction would result in lower worker exposure to toxic chemicals, fewer transportation accidents involving hazardous substances, and fewer hazardous consumer products. **Increasing numbers of successful examples of waste reduction yielding net cost savings and more competitive operations support the argument that waste reduction promotes industrial revitalization and economic growth.** For all these reasons ample justification, going well beyond environmental imperatives, can be cited for a strong Federal role in waste reduction. (Although discussions of public roles usually focus on Federal and State government, it should be noted that local governments are increasingly encouraging more waste reduction by local companies.)

In the private sector, the interests and actions of several groups must be considered:

1. the insurance industry may require plans and commitments for waste reduction as a condition for obtaining pollution liability insurance, which is now difficult and costly to obtain;
2. financial institutions may use waste reduction plans and performance as criteria to judge the merits of borrowers; if they view investments for waste reduction in the same way as they view traditional investments for expansion and modernization, then waste reduction efforts will be aided;
3. some environmental organizations and public interest groups are now making waste reduction a high-priority issue and are educat-

[a]Here and in similar subsequent statements about industry's viewpoints, reference is being made to the results of an OTA survey of industry people directly involved with waste management and reduction (see app. A of the full report).

Table 1.—1984 Amendments to RCRA on Waste Minimization (WM): Problems in the Statute, Regulations, and Implementation

		Implementation	
The statute	Regulations	By EPA	By States
1. Policy and administration			
Primacy of waste reduction made clear by strong *national policy* outlining a two-tier approach: pollution prevention (waste reduction) and pollution control (preferred waste management practices) to minimize risk. No economic test to limit activities.	National policy was not restated in preamble.	EPA views WM as minor component of land disposal bans. Little oversight of implementation by EPA HQ; no WM budget commitment. EPA assumes States are handling implementation of regulations even though EPA is required to do so until States are authorized.	States not responsible for implementation until authorized.
2. Definitions and measurement			
Ambiguous phrasing in implementation sections. WM can be interpreted as either: 1) reducing the generation of waste (prevention), or 2) reducing waste that is generated (control). This definition erodes primacy of waste reduction and causes uncertainty in measurement. Economic/technological limits placed on required WM activities: "economically practical" waste reduction and "practical available" waste management.	Primacy of waste reduction eroded by ambiguous phrasing carried over into regulations. Waste minimization, waste reduction, waste management are not defined; results in high uncertainty among regulators and generators as to what constitutes WM.	EPA did not supplement statutory/regulatory language by issuing broad guidelines as to what constitutes WM or how it should be measured. Other actions/statements by EPA imply WM is any activity that will reduce wastes *before* or *after* generated.	States use different definitions, with focus usually on preferred waste management to reduce need for land disposal facilities.
3. Required actions	*1) Manifest certification*		
Implementation sections mandate three actions: 1) WM certification on manifests, 2) WM activities/results statement added to biennial report, and 3) annual WM statement by generators managing wastes onsite.	All generators who ship wastes offsite must sign WM certification statement on new manifest form.	No leadership from EPA.	States generally picked up use of new manifest with WM certification or adopted language for own manifest.

Table 1.—1984 Amendments to RCRA on Waste Minimization (WM): Problems in the Statute, Regulations, and Implementation—Continued

The statute	Regulations	Implementation	
		By EPA	By States
Each action as written includes waste reduction and preferred waste management components; however, primacy of waste reduction over preferred waste management not clear. Having WM program in place is not a required activity for biennial reporting.	*2) Biennial report* Only generators who ship wastes offsite (subset of Nation's total generation) required to report WM activities in biennial reporting. No reporting guidelines issued with regulations.	Reports covering waste generation in 1985 due March 1, 1986. Little guidance given to generators/ States on what constitutes a WM program. Form required only narrative statement. Results: 1) no data likely to be collected, or 2) no consistency in reporting. Little followup evaluation will be possible on effectiveness of regulations.	Most States collected what information assumed required. A few asked generators to supply supplemental information. Information remains at State level; EPA did not request submission of WM information in required biennial report summary.
	3) Permit condition Generators who treat, store, dispose of wastes onsite subject to TSDF permits. Permits now require annual statement on WM program to be placed in operating file onsite.	Lack of definition/guidelines has created variability among regions. Regions/generators unsure about what constitutes a WM program statement.	WM condition of permit primarily handled by EPA regions rather than States.
4. Enforcement Enforcement not mandated. Generators allowed to determine activities that constitute WM.	EPA stated in preamble to regulations that would only attempt enforcement of manifest certification.	No apparent enforcement underway. Minimum enforcement would require visits to generators and TSDFs to ascertain if manifest WM statement signed or operating record contains annual WM program information. Since generators determine activities, compliance would not indicate if waste reduction has occurred.	Enforcement activities unknown.

SOURCE: Office of Technology Assessment, 1986.

ing the public about its importance as well as trying to influence government and industry decisions and programs; and

4. various organizations offer seminars, short courses, and conferences, which bring attention to waste reduction and transfer technical information to people in industry.

Although it has not been possible for this study to examine in detail the potential impact of these embryonic private sector efforts, it is evident that they are destined to play an important role in stimulating industrial waste reduction nationwide. The role of the news media is less certain. There is already evidence that waste reduction is not deemed as newsworthy as the more visual aspects of pollution control, particularly its failures. For example, companies that have won honors for successful waste reduction have received little, if any, news coverage—unlike those that have polluted the environment. The company that is not generating waste provides scant fodder for reporters and few photographic opportunities for cameramen.

What does all this mean in terms of congressional action? With regard to industry, common sense suggests that massive reduction of waste is not possible overnight. But available information supports the view that eventually large-scale waste reduction will be possible technically and economically. Supportive private sector efforts, which are just now being initiated, are likely to promote more waste reduction by industry. **Commitment to the national policy goal and well-informed planning for its implementation can be assisted by Federal leadership.** But how much waste reduction is possible? Exactly how much has been going on? What are its economic and environmental benefits? These important questions cannot now be answered with detailed, reliable data. Nor is it possible to quantitatively calculate the positive and negative impacts of certain government actions on specific wastes or industrial waste generators. These limitations do not necessarily rule out Federal leadership, but they do favor some types of government action over others.

The Primacy Issue

For the Environmental Protection Agency (EPA), industry, and environmentalists, waste reduction has consistently appeared as the ideal waste management option—the *concept* is universally embraced even though the option is not vigorously implemented. Even though EPA acknowledged that waste reduction should be given top priority in 1976,[9] this theoretical priority has not been matched either by action or by resources. Now that the implementation of waste reduction is receiving more attention, the fact that its definition has not been made clear poses a serious problem.

Ironically, the goal of reducing the use of land disposal detracts from the goal of reducing waste. If waste reduction is defined to include waste treatment, then attention is diverted away from true waste reduction.

[9] 41 CFR 35050 (Aug. 18, 1976).

The goal of waste reduction subsumes the goal of reducing land disposal, but the goal of reducing land disposal does not mean that the alternative chosen will be waste reduction.

EPA and State agencies spend at most about $5 million annually on activities related to waste reduction. This is less than 0.1 percent of total government spending on pollution control programs. The Department of Defense, however, has committed larger sums of money for waste minimization, but they define it to include waste treatment (see ch. 5 of the full report).

Industry probably spends significant sums on waste reduction—possibly a much greater percentage of its environmental spending than the government allots, although these figures cannot be determined. **Waste reduction tends to lose out to waste management in the press of immediate concerns,** such as siting waste management facilities, developing alternatives to land disposal, and determining safe levels of emissions. Little recognition is given to the fact that effective waste reduction methods can lessen these needs. **Pollution control is often perceived as being the safer choice because the technologies of waste management are more familiar than those of waste reduction and there is no risk of impairing product quality. In actuality, there is no such risk with many ways of reducing waste.**

Some waste generators say that they have reduced their wastes as far as is feasible; others believe that waste reduction makes sense only in the longer term. **Waste reduction is often seen as a long-term ideal rather than as an immediate and practical route for industry and government to pursue.** This appears to be primarily a consequence of resource commitment to and familiarity with pollution control rather than to technical constraints.

Many industry actions have some potential for promoting or hindering waste reduction, but these are rarely examined explicitly. **Waste reduction is seldom seen as a criterion to measure job performance or performance in meeting government environmental protection requirements, developing production technologies, and setting research agendas.** Offering rewards and incentives for workers and managers who find ways to reduce waste can be an especially important strategy.

Goals for waste reduction could be established just as, for example, people target a certain annual increase in the gross national product or in productivity. Goals could help maintain interest in reducing waste. Some companies report involvement in goal-setting,[10] but for the most part, **there has been little use of the technique of setting target figures for waste reduction at the plant, company, industry, or national level.**

[10]Some companies have said that they do not use numerical goals, while others indicate that they may use them. For example, 3M has said that it reduced potential hazardous waste generation by 50 percent in the past 10 years and that it hoped to repeat that in the next 5 years. Chevron Chemical Co. has said that specific waste reduction goals are set by each of its plants. [*Waste Reduction: The Untold Story*, proceedings of a League of Women Voters conference, Woods Hole, MA, June 1985.] Du Pont has also announced that it is preparing a goal for 1990. The Department of Defense is preparing waste reduction goals.

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The Case for the Primacy of Waste Reduction

Why should waste reduction be given primacy over waste management by industry? Excluding the factors of transport and storage, waste management can be divided into three categories: 1) recycling or reuse away from the source of waste generation; 2) treatment or conversion, which physically destroys or chemically detoxifies or otherwise renders waste permanently harmless; and 3) disposal, which puts waste into the air, water, or land. Environmental regulation has not necessarily required the first two preferable options and has often led inadvertently to very ineffective disposal which has caused problems so severe as to have necessitated repeated redisposal. However, if a treatment permanently renders all or most waste harmless, then it is *effective waste treatment*—i.e., its benefits approach those of waste reduction. Both offsite recycling and effective waste treatment are preferred waste management options, but both pose more risks than waste reduction because waste is handled, stored, and transported. The possibility of mismanagement or failure of technology cannot be disregarded. Accidents can occur at both recycling and waste treatment facilities, threatening workers or permitting hazardous wastes to enter the environment and threaten local communities.

The limited data available indicate that most RCRA hazardous waste is still land disposed—by one estimate for 1983, 68 percent was deposited in or on the land[11]—and available data for the past several years do not yet show a major shift away from land disposal. Less than 2 percent of RCRA regulated waste is incinerated, and not much more is permanently treated in other ways or recycled. Sometimes data for a company or an industry show a drop in land disposed waste, but this may be due to declining production.

Often what is called treatment of waste is simply removal and transfer. For example, evaporation ponds and air stripping columns used for treating liquid wastes purposefully put volatile toxic chemicals into the air, and adsorption materials used to remove toxic chemicals from liquids or gases are generally land disposed. Statistics for industrial hazardous pollutants in waste streams sent to publicly owned water *treatment* plants indicate that only about 50 percent are permanently altered; the rest remain hazardous and are released into the air as volatile emissions, discharged into surface waters, or put into the land as sludge, where hazardous substances can migrate into groundwater.[12] There are concerns about emissions of unregulated toxic chemicals resulting from incineration; according to EPA more than half of hazardous waste incinerators in 1981 used no air pollution control systems at all.[13]

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[11]U.S. Congress, Congressional Budget Office, *Hazardous Waste Management: Recent Changes and Policy Alternatives* (Washington, DC: U.S. Government Printing Office, May 1985).

[12]U.S. Environmental Protection Agency, *Report to Congress on the Discharge of Hazardous Wastes to Publicly Owned Treatment Works*, EPA/530-SW-86-004 (Washington, DC: Office of Water Regulations and Standards, February 1986), p. 7-6.

[13]E. Timothy Oppelt, "Hazardous Waste Destruction," *Environmental Science and Technology*, vol. 20, No. 4, April 1986, pp. 312-318.

The widespread potential for cross-media transfer in waste management and treatment is an important reason for giving primacy to waste reduction. Two examples illustrate how existing environmental programs can lead to cross-media transfers of pollutants:

1. Air pollution and water pollution control or treatment techniques produce hazardous solid waste such as baghouse dusts and sludges that include toxic metals, often in very large quantities. At one major commercial hazardous waste landfill these types of wastes accounted for 25 percent of its receipts in 1984. At a major petroleum refinery, fully 60 percent of all the hazardous wastes come from required air and water pollution control devices.
2. Solid waste surface impoundments, landfills, water treatment units, and some cleanups of contaminated groundwater and soil release unregulated toxic air emissions. An EPA study found the Northeast Philadelphia Sewage Treatment Plant to be the largest single source of air toxics in the entire metropolitan area, greater than such major industrial facilities as refineries and chemical plants.

Another reason for giving primacy to waste reduction is that the current regulatory system sanctions the generation of certain amounts of waste, and these can accumulate to environmentally unacceptable levels when postpollution control discharges from many generators enter the environment. Regulatory permits given to a generator for specific wastes are not necessarily based on standards, but rather on what is technically feasible for the generator. Nor is there necessarily effective enforcement of the limits imposed by permits. Moreover, certain kinds of wastes, such as toxic chemicals, are not necessarily covered by permits geared to conventional pollutants. The result is that large amounts of legal and illegal waste discharges are entering the environment. For example, an EPA study found that over 3,000 tons of toxic metals were entering the Chesapeake Bay annually from industries in Maryland and Virginia. Many believe that cumulative discharges of hazardous waste have played a role in the declining marine life of the Bay. (For example, even while environmental regulations escalated, commercial catches of striped bass fell from 6 million pounds in 1970 to 600,000 pounds in 1983. Oyster harvests have dropped by two-thirds in the last 20 years.)[14]

In sum, to an unacceptable degree, hazardous waste management involves disposal or dispersal of waste into the environment. Some of this pollution may not be too troublesome. For example, the atmosphere or the ocean may be able to assimilate fairly large quantities of some substances without causing harm to the environment or to human health. But much of this disposal or dispersal into air and water is known to pose severe environmental threats. Many land disposal practices, which have been proven harmful, illustrate this point. In many other cases, the long-range effects of disposal and dispersal practices can only be classified as unknown. Effective waste treatment is often expensive,

[14]"The Poisoning of Chesapeake Bay," *The Washington Post*, June 1, 1986, p. 1.

which is why most wastes are not treated effectively. Even when new technology makes lower costs possible, firms offering these technologies often encounter market entry problems that limit the availability of these methods. For example, there is a host of technical, economic, and institutional explanations for the fact that recycling is not used more widely. Waste disposal, which generally has the lowest direct cost, should be permitted only when the user is able to demonstrate that waste disposal will accomplish environmental protection and that no costs will be shifted to other parties. But at present waste generators often only have to deal with the *immediate* costs of land disposal, and government still sanctions its use for many wastes rather than limiting it to the residues of treatment, which will always require land disposal.

The most important reason why waste reduction should be the first option of generators is because all waste treatment and recycling facilities pose some environmental risk and thus require effective regulation. The most certain means of preventing environmental risk is through waste reduction. Waste reduction is also preferable to most waste management practices because it can lead to lower direct costs and higher indirect benefits. As a recent report by the French Government said: "Avoiding the creation of pollution seems to be the best way to fight against it, technically and economically."[15] Similarly, analysts in the U.S. waste management industry studying alternatives to land disposal of hazardous waste recently concluded:

> Obviously, the most preferred is the prevention of generation. This option usually is the least costly and does not require other management options, such as detoxification or volume reduction.[16]

If waste reduction has primacy, then: 1) its possibilities should always be thoroughly explored before waste management is used, and 2) the allocation of public and private resources should reflect its priority. As will be discussed later with regard to technology, the fact is that significant waste reduction *is* underway and experience in the United States and elsewhere indicates that **waste reduction is a near-term practical option,** even though it is not possible to estimate accurately the upper limit of how much is technically and economically feasible.

THE INTERNATIONAL DIMENSION

Have other nations also come to the conclusion that waste reduction is important? The degree of interest in waste reduction among governments in other industrialized nations varies (see app. B in the full report). Some governments have taken little or no action. The United Kingdom, for example, has decided to concentrate its efforts on ensuring

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[15]Michael R. Overcash, *Techniques for Industrial Pollution Prevention* (Chelsea, MI: Lewis Publishers, Inc., 1986), p. 29. Based on Ministere de l'Environnement, *Les Techniques Propres dans l'Industrie Francaise*, translated by Michelle L. DeHertogh.

[16]R.J. Schoenberger and M.H. Corbin, "Technologies for Hazardous Waste Reduction—A State of the Art Review," paper presented at Third Hazardous Waste Management Conference, Philadephia, PA, June 1985.

adequate waste management, while Japan has concentrated on promoting reuse or recycling technologies. Other governments are just beginning to take action. Canada has, until recently, left waste reduction up to its Provinces. Ontario, for example, has initiated substantial waste reduction efforts. This situation is likely to change, however; the Canadian Federal Government will be holding a major policy planning meeting in October 1986 to outline a plan for coordinated Federal and Provincial action on waste reduction.

Most European governments (e.g., France, the Federal Republic of Germany, Sweden, Norway, Denmark, The Netherlands, and Austria) have exercised more leadership in waste reduction and have devoted more money to waste reduction than the United States. While the development of governmental programs to promote waste reduction dates from the early 1980s in the United States, these West European countries have been supporting the concept of "low- and non-waste technologies" (or "clean technologies") since the 1970s. As is the case here, there are no data from European countries on which to base an assessment of waste reduction, so it is impossible to know if government activity has resulted in higher levels of reduction there than here. Differences in definitions for hazardous waste and waste reduction also hamper comparisons both between Europe and the United States and among European nations. However, it is important to note that European nations have generally not established as extensive environmental regulatory programs as has the United States. This absence of a pollution control culture may have helped to facilitate interest and investment by Europeans in waste reduction.

The experiences of these governments in promoting waste reduction among their industries may be instructive to U.S. policymakers. European governments have focused on assistance to and cooperation with waste generators as well as on government and industrial planning for waste reduction. This is consistent with their nonregulatory approach to environmental protection.

West European experiences may also present a challenge to the United States because waste reduction has been used as a tool to improve industrial efficiency, growth, and international competitiveness and not solely for environmental protection. Some U.S. firms have also taken this position. For example, a Du Pont executive has said:

> Waste reduction can also give us a leg up competitively. In the past, few companies factored the costs of waste disposal into their manufacturing processes. Today, an economical and environmentally acceptable plan for waste management may well make Du Pont the low-cost producer—and hold the key to the success or failure of many of our businesses.[17]

[17]Paul A. Chubb, *Wasteline*, Spring 1986. This publication is Du Pont's new waste reduction newsletter.

To the extent that Europe's lead in waste reduction results in more efficient processes and increased productivity among European industries, U.S. firms in similar industrial sectors may be placed in an inferior competitive position. In addition, to the extent that a profitable worldwide market for waste reducing technologies and techniques opens up in the coming decade, U.S. firms may find it difficult to sell their waste reduction expertise to industrial operations here and overseas if Europeans are offering a wider variety of better techniques that have been tested over a longer period of time.

ISSUES AND FINDINGS

To summarize the material in the full report, OTA has defined eight issues which are presented here together with OTA's findings and brief explanatory discussions.

SUMMARY ISSUE 1:
Is waste reduction measured correctly in common practice?

OTA Finding:

Some companies do measure waste reduction correctly. They determine how the generation of a specific waste from a process has changed over time by reference to a unit production output. It is even more useful to determine how specific hazardous substances within the waste have changed, again on a unit production basis. For a new process or product, the levels of waste generation that occur with waste reduction measures should be compared to what would have been generated without waste reduction. No current public database on waste generation is coupled with information on production output and no significant amounts of disaggregated (i.e., plant- and process-specific) waste reduction data are in the public domain. Waste generation information is thus likely to be misleading about waste reduction.

Discussion

A major problem in analyzing waste reduction is deciding exactly how it should be measured and described. **Waste reduction is far more difficult to document with meaningful data than it is to talk about in general terms.** Most of the limited data on waste generation available to policy analysts are too aggregated over processes, plants, companies, and sometimes industries to prove or disprove that any given degree of waste reduction is taking place. Moreover, the national database on the *generation* of hazardous waste is in very poor condition. Ten years after RCRA was enacted, the data on waste generation are generally accepted to be incomplete, out of date, unreliable, and sadly lacking in detail. EPA itself has recently said that: "vital data and ana-

lytical techniques are still lacking."[18] Only a few States have information that is more useful than that in the national database.

For hazardous wastes not regulated by RCRA, the situation is no better. The most obvious problem is that of toxic air emissions; there is no reliable database for the range of toxic chemicals being released in large quantities into the atmosphere.[19] As to water, there has been no systematic nationwide collection of data on the actual (rather than permitted) levels of discharges for the full range of wastes, nor has there been a tally of permitted levels.

In other words, the current pollution control regulatory program has not given the Federal Government the sort of extensive data that will chart exactly what wastes are coming out of every industrial operation. It is not at all clear that even plant operators usually have this information.

Because almost everyone in the regulatory agencies and industry has been preoccupied with pollution control, the focus has been on amounts of waste generated. When interest shifts to waste reduction, however, statistics on the absolute amounts of waste generated do not suffice. **The problem in examining any waste generation data (national, State, or company level) is that over time industrial activity changes, product mix changes, and environmental regulatory requirements (which determine what is counted as a waste) change; all three factors strongly affect waste generation figures. Increasing economic activity and production might mask waste reduction. Alternatively, aggregated waste generation data which show a decline over time may result from a recession or from treatments that change waste volume, such as dewatering and waste stream separation, without any reduction in toxicity or level of hazard.** If one major industrial plant maintains a very high volume aqueous waste stream this can greatly affect aggregated data for an industry segment on a State or even national basis.[20] Although they may greatly reduce waste management costs to the generator, *actions that reduce waste volume by concentrating the hazardous content of a waste or that reduce hazard level by diluting the hazardous content are not considered waste reduction in this report.*

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[18]Gary M. Katz, Director, Management and Organization Division, U.S. Environmental Protection Agency, memorandum on "Reorganization of the Office of Solid Waste," to Howard M. Messner, Assistant Administrator, May 7, 1986, attachment 1.

[19]For example, in an unusually candid EPA document, the quality of the Nation's air toxics emissions data was discussed. Comments included: " . . . the emissions data base for air toxics is quite poor . . . " "There are presently no continuing and comprehensive Federal emission inventory data bases maintained on air toxics. There are no regularly updated, computerized, emission inventory systems . . . " "The existing air toxics emissions summaries come from a hodgepodge of EPA reports, articles, etc." [Tom Lahre, Office of Air Quality Planning and Standards, U.S. Environmental Protection Agency, "Characterization of Available Nationwide Air Toxics Emissions Data," June 13, 1984.]

[20]For example, data over a 4-year period for 324 chemical plants indicate that solid hazardous waste decreased from 3.3 million tons in 1981 to 1.3 million tons in 1984, and hazardous wastewater decreased from 207.8 million tons in 1981 to 175.2 million tons in 1984. Some of this decline in waste generation is undoubtedly a result of waste reduction. However, concentration of hazardous substances, changes in production levels, and other factors may also contribute to the changes. [Chemical Manufacturers Association, "Results of the 1984 CMA Hazardous Waste Survey," January 1986.]

A good measure of waste reduction might be on a process basis, such as the amount of waste per hour of electroplating; an even better measure may be based on production, such as the amount of waste produced per pound of chemical or per computer. Indeed, several companies have said that putting waste generation on a production output basis is how they measure waste reduction.[21]

Consider data from the Sanford, North Carolina, plating operation of Stanadyne, Inc. From 1983 to 1985 waste sludge decreased from 115,000 pounds to 110,000 pounds, just over 4 percent. But production hours had increased from 2,380 to 4,550. Waste generation in terms of production output dropped from 48.3 pounds per hour to 24.2 pounds per hour, almost a 50-percent decrease. This is the correct measure of waste reduction. Even if waste generation had increased 30 percent to 150,000 pounds in 1985, there still would have been 32-percent real waste reduction. In other words, the correct measure of waste reduction provides a remarkably good indication of the level of efficient use of materials in industrial operations.

One problem with this method is that **putting waste reduction on a production output basis raises concerns in companies about revealing information they consider confidential. However, it is not necessary to report actual production data. All that is necessary is to give the final waste reduction percentage based on waste generation *and* production data, *not* based solely on changes in the absolute amounts of waste generated.**

Disaggregated waste percentage data can then be pooled to obtain weighted (in terms of relative amounts of waste) waste reduction averages over a number of processes or operations, or even plants of a company, or companies of an industry (see box D). This kind of averaging, or pooling, gives a true measure of waste reduction and avoids proprietary problems. The key is to come up with disaggregated percent waste reduction figures that are clearly understood to be derived from production-based waste generation data; without the production base there can be no valid measure of waste reduction.

There is one more critical problem in the measurement of waste reduction, even when using the approach just discussed. In the above example, there was an implicit assumption that the chemical nature of the waste did not change. If a waste is not totally eliminated, how-

[21] *Waste Reduction—The Untold Story*, proceedings of a League of Women Voters conference, Woods Hole, MA, June 1985. But no detailed waste reduction data on a production output basis are given, although Monsanto Co. noted: "Absolute total waste generation volume decreased only 1.7 percent from 1982 (our 'base year') through 1984. Unit generation, however (pounds of waste/pounds of production), decreased *19.7 percent!*" This illustrates how important it is to put waste reduction on a production output basis. There were other examples, in answer to a question on how waste reduction is defined. Exxon Chemical Americas said: "Also use an index of tons of waste divided by tons of product produced for comparison on a year to year basis. This index properly considers growth via new products or additional production. This index is similar to commonly used energy indexes." Du Pont said: "Amount reduced per ton of product—i.e., waste could increase in pounds, but still be reduced as a fraction of production." Olin Corp. said: "Reduction in quantity of waste generated per unit of product produced." Amoco Chemicals Corp. said: " . . . waste reduction is . . . a decrease in the amount of waste requiring disposal per unit of product produced."

Box D.—The Measurement of Waste Reduction

Case #1: Waste reduction for a specific waste generating industrial process or operation for which a production output can be identified and there is no change in the chemical makeup of the waste.

Percent Waste Reduction = WR = [(A - B)/A] × 100

where,

A = amount of previous waste generated/production output

B = amount of new waste generated/production output

Example calculation, given that:

in year	*chemical produced*	*waste generated*
1984	500,000 pounds	50,000 pounds
1985	600,000 pounds	40,000 pounds

then:

A = 50,000/500,000 = 0.1

B = 40,000/600,000 = 0.07

and

WR = [(0.1 - 0.07)/0.1] × 100 = 30 percent waste reduction

Thus, waste was reduced by 30 percent on a production output basis from 1984 to 1985 while chemical production increased 100,000 pounds (20 percent). If waste generated in 1985 had been 55,000 pounds (i.e., an absolute increase of 10 percent in amount of waste generated), then on a production output basis there would still have been waste reduction since:

A = 0.1

B = 55,000/600,000 = 0.09

and

WR = [(0.1 - 0.09)/0.1] × 100 = 10 percent waste reduction

Case #2: Waste reduction for a plant with more than one waste generating process or operation.

Overall Percent Waste Reduction = WRtotal =

[M1/Mtot)WR1 + (M2/Mtot)WR2 + (M3/Mtot]WR3 + (Mn/Mtot)WRn

where,

Mn = amount of waste from nth (first, second, third, . . . nth) waste generating process or operation

Mtot = total amount of waste generated in plant operations

WRn = percent waste reduction from the nth waste generating process or operation

Case #3: Waste reduction for a company with more than one waste generating plant or an industry with more than one waste generating company would be calculated as above, with the weighted percent waste reduction figures for the plants or companies and Mtot for the company or industry.

ever, actions taken to reduce waste may also change the chemical composition and the concentrations of the components of the waste. Therefore, *examining changes in just the amount of waste generated relative to production may not reveal whether there has been a change in the degree of hazard of the waste.* Without a decrease in the degree of hazard of the waste, the action is not considered waste reduction. For example, as mentioned previously, large aqueous waste streams are generated by the chemical industry; some actions can reduce the water content but not the amount of hazardous substances in the waste. Dewatering of a sludge is another example of reducing the volume and concentrating the hazardous content of a waste. Neither case should be considered waste reduction.

Some waste reduction actions, such as changing process technology, may reduce some hazardous components but increase others or introduce new ones. Unless the basic chemistry of a waste has remained constant, waste reduction data may not accurately indicate what has occurred.[22] Several questions need to be answered in order to flag suspect or meaningless waste reduction data: Has the waste reduction resulted from an action that concentrated hazardous content? Has the waste reduction resulted from an action that changed the chemistry of the waste? Has the waste reduction resulted from some unknown activity? Unless a negative answer can be given to these questions with certainty, the bare waste reduction data (on a production output basis) may not accurately reflect what OTA defines as true waste reduction. To go much beyond asking these simple questions would, however, require considerable analytical effort.

The best way to measure waste reduction is to determine the changes in the absolute amounts of hazardous components. This is considerably more expensive than obtaining data on changes in the total amounts of waste. Without guidance on the relative degrees of hazard of specific hazardous substances, waste generators could face burdensome analytical costs for periodic measurements of the complete chemistry of their wastes, which may be highly complex and vary over time. The current regulatory system has, for the most part, done little to differentiate hazard levels among the many hundreds of common hazardous substances. Therefore, if the government is to encourage effective waste reduction, it may have to assist generators in selecting the most hazardous components of wastes for measurement and reduction. The National Research Council stated:

> To encourage waste reduction practices, the committee recommends modification to the regulatory definitions to include the degree of hazard.[23]

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[22]This is also the case if a "dry weight" of an aqueous waste is used. While changes in dry weight avoid the problem of reporting changes in water content only, they do not necessarily reveal changes in the hazardous content of the nonaqueous portion of the waste.

[23]National Research Council, *Reducing Hazardous Waste Generation* (Washington, DC: National Academy Press, 1985), p. 31.

If the government does not establish a means to differentiate among hazardous substances, then using changes in the amount of waste on a production output basis in combination with flagging data that should be excluded is the best compromise. This method would also be a substantial improvement over the current practice of making measurements of waste generation that are uncorrected for changes in production output.

SUMMARY ISSUE 2:
Is the absence of solid information on waste reduction a barrier to government and industry's ability to take initiatives to step up waste reduction?

OTA Finding:

Rather than delaying waste reduction while more data are collected, the development of better information can be made part of waste reduction programs. An information gap does not have to be a barrier to waste reduction initiatives by government and industry, but initiatives should emphasize the need for acquiring better information to document their effectiveness and progress. Even if the government were to take no further action, there would still be a critical need to obtain information on the national waste reduction effort.

Discussion

Opinions about the current state of waste reduction—how much is possible, and whether further government action is needed—are based almost entirely on perceptions, anecdotes, and examples rather than on systematic data. Only a monumental government effort could compile systematic and reliable data on waste reduction for American industry. *The experience with the RCRA waste generation data system shows that it would be remarkably difficult for government to gather and analyze accurate and timely data from a very large number of companies and for an even larger number of processes and waste streams.* Even reliable data would not reveal what actions, out of a broad range of possibilities, a *specific* industrial operation might reasonably undertake to reduce waste, because so much of what is technically and economically feasible is site-specific.

The costs and benefits of overcoming these obstacles are difficult to assess but are probably substantial. Nevertheless, this uncertainty and the *time* it would take to put together extensive data on waste reduction do little to resolve current questions, which must be addressed in formulating policy recommendations. Should government pursue some direct approach for spurring waste reduction in the near term? Or should it wait and give the system a chance to respond to current indirect incentives (which are working to some extent)?

SUMMARY ISSUE 3:
Can industry implement waste reduction while remaining in compliance with pollution control regulations?

OTA Finding:

Environmental protection argues for simultaneous efforts toward reduction and control. But practical limits to industrial resources suggest that many waste generators may need regulatory flexibility and technical assistance to permit a smooth transition from pollution control to waste reduction.

Discussion

The current state of waste reduction in industry raises a number of issues for industry itself, for government, and for other individuals or organizations interested in examining waste reduction. In industry, as in government, waste reduction has generally been a part of existing pollution control efforts. **Companies with major waste reduction programs, however, often shift waste reduction to the production arena.** The historical linkage of waste reduction to pollution control may be one of the obstacles faced by government and industry in their attempts to promote widespread waste reduction.

For example, Federal regulatory programs in themselves are sometimes counterproductive or inattentive to waste reduction; they are mostly driven by available, proven pollution control technology rather than by health and environmental considerations. This means that certain levels of waste generation are approved by regulations. The result, therefore, is that end-of-pipe regulatory programs legally allow the generation of hazardous waste and do not *directly* stimulate waste reduction. **Of course, the pollution control approach does offer environmental protection. Waste reduction, however, offers more, and the government's approach to environmental protection has kept attention and resources from being directed towards waste reduction.**

Telling industry to comply with pollution control regulations and simultaneously reduce waste ignores practical limits to industrial resources. Regulatory compliance is expensive. For many companies, capital investments for pollution control and the costs of regulatory compliance can foreclose any but the simplest efforts at waste reduction, even though successful waste reduction will very quickly reduce regulatory compliance and waste management costs. **The difficulty for a generator, then, is to continue to invest and spend on regulatory compliance and improved waste management while at the same time investing and spending on waste reduction.** It seems like a Catch-22 situation. The answer may be not to force a choice between waste reduction and pollution control. If flexibility can be introduced into the current regulatory system and if assistance for waste reduction is offered, switching emphasis over to waste reduction can be facilitated. But while the transition is being made, environmental protection must be maintained.

As discussed in chapter 3 of the full report, there is no question that waste generators will unavoidably face an investment-uncertainty hurdle as they proceed with waste reduction.

SUMMARY ISSUE 4:
Has U.S. industry reduced the generation of hazardous waste to the greatest degree possible?

OTA Finding:

Waste reduction is a dynamic opportunity contingent on a host of changing technical, economic, human, and institutional factors. Thus, substantially more waste reduction is feasible and more will become feasible. Setting a national voluntary waste reduction goal of 10 percent annually for 5 years could be useful.

Discussion

Some companies believe that there are few if any remaining waste reduction opportunities. In particular, some larger companies feel that they have accomplished all the waste reduction that they can. Many of industry's statements about waste reduction are reminiscent of 1970's statements about industrial energy conservation. What this means is that, to a significant extent, **waste reduction may be blocked by individual attitudes based on limited information and experience, rather than on lack of effective technology.**

- Are managers, design engineers, researchers, and plant engineers and workers familiar with all the technical means to reduce waste?
- Have they examined all waste reduction opportunities? Does their organization reward waste reduction efforts?
- Have they been able to see the economic value of a waste in terms of its worth as wasted raw material and its costs as a pollutant to be managed and as a potential liability?
- Do environmental engineers who are trained in and preoccupied with end-of-pipe management consider front-end changes? Are they technically equipped to recognize waste reduction opportunities throughout a process?
- Are traditional mass or material balance calculations, which some companies perform to describe inputs and outputs, sensitive enough to reveal small amounts of waste that may be of great economic and environmental significance?
- Do companies consider reducing all wastes, including those that are unregulated or are currently released into the environment according to the limits imposed by a permit?

While no generalization is correct for all companies, OTA finds that for the most part the answer to all the above questions is "no." The conclusion is that there are substantial opportunities for waste reduction, even though it is not possible to give numbers for specific wastes

and industries. **The challenge is to persuade and assist most American waste generators to do what a few companies have already discovered is in their own economic self-interest.**

Rather than attempting to forecast future amounts of waste reduction, which cannot be done with accuracy because of the nearly unbounded methods of implementation and because of site-specific limitations, **it might be more useful to focus on a voluntary waste reduction goal. Government could set, for example, a goal of 10 percent annually over 5 years for plants, companies, and the Nation as a whole. This level of activity appears feasible, based on reports of recent successful efforts.** For example, a survey asked various large companies whether, after accounting for production changes, waste generation had decreased from 1984 to 1985. The answers are impressive. The percentage reductions reported are: Rohm & Haas, 10 percent; Exxon Chemical Americas, 10 percent; Olin, 34 percent from 1981 to 1985; Du Pont, 50 percent and 35 percent for two divisions; 3M, 50 percent over 1975 to 1985; and two companies, which did not put data on a production output basis, indicated that generation dropped: IBM reported a drop of 17 percent; Hewlett Packard, 16 percent for the years 1983 to 1984.[24] Naturally, not every waste generator would be able to match figures such as these. **If a national goal were to be set, it should not be as a regulatory requirement, but as a way to stimulate interested and informed support for implementing waste reduction.**

It is difficult to know, however, how far publicized waste reduction success stories can be extrapolated. Companies that are not pursuing waste reduction goals normally remain silent. Some companies do not agree with this optimistic view of waste reduction possibilities because they feel that limitations are posed by their site or their history. However, most people working in the field are optimistic about the potential for waste reduction. A recent major study of waste reduction in 29 organic chemical plants is significant.[25] Some of its findings were:

> . . . despite the kinds of benefits companies could reap from waste reduction, and despite all the talk about the critical importance of this strategy by those in and outside the industry, waste reduction initiatives were actually affecting only a tiny fraction of the total wastes generated by our 29 plants. It is our belief that virtually every facility generating wastes in the form of air emissions, wastewaters and solids has substantial and beneficial opportunities to pursue waste reduction at the source.[26]

Another study of waste reduction made the same point:

> . . . most of the industrial efforts in the nation are currently in the initial phase in the development and implementation of hazardous waste reduction programs. Significant opportunities exist to reduce the generation of hazardous waste . . .[27]

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[24]*Waste Reduction—The Ongoing Saga*, proceedings of a Tufts University Center for Environmental Management conference, Woods Hole, MA, June 1986.

[25]David Sarokin, et al., *Cutting Chemical Wastes* (New York: INFORM, 1985).

[26]David Sarokin, "Waste Reduction in the Organic Chemical Industry," paper presented at Government Institutes' Hazardous and Solid Waste Minimization Conference, May 1986.

[27]National Research Council, *Reducing Hazardous Waste Generation* (Washington, DC: National Academy Press, 1985), p. 5.

A Du Pont official recently said:

> We will see considerable reductions in the percentage of waste generated per pound of product produced, just as we have seen reductions in the consumption of energy over the last ten years.[28]

Finally, a senior EPA official recently said: "Principally, I agree that not enough waste reduction is going on at present."[29] The Department of Defense is establishing goals for large amounts of waste reduction.

SUMMARY ISSUE 5: Do technological limitations pose a major obstacle to waste reduction?

OTA Finding:

> The phrase *waste reduction technology* is misleading. It is more useful to think of waste reduction in terms of a wide range of latent technological opportunities that exist throughout the production system. These opportunities can be taken advantage of with a spectrum of technical means that vary greatly in technical complexity, cost, and effectiveness. The technical and economic feasibility of waste reduction has meaning only in the context of and from the perspective of a specific industrial plant operation. While some means of waste reduction are transferable from one site to another, it cannot be assumed that what works at one place will be both technically and economically feasible at another. However, there are some waste reduction opportunities that are broadly applicable because they employ commonly used materials and are effective for commonly used processes.

Discussion

OTA has concluded that waste reduction should be viewed as a criterion to assess almost any industrial process and operation rather than as a unique type of technology, machine, or even field of expertise (see ch. 3 of the full report). **The technological means to reduce waste are imbedded in all aspects of the production system.** Therefore, the phrase *waste reduction technology*, although it is convenient to use, can lead to confusion. Five classes of waste reduction are identified in this study:

1. recycling of a [potential] waste or part of it at the site of its generation;
2. improvements in process technology and equipment that alter the primary source of waste generation;
3. improvements in plant operations (e.g., better housekeeping, improved materials handling and equipment maintenance, better monitoring and automation of process equipment, and improved waste tracking or mass balances);

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[28]J. Howard Todd, "Waste Reduction . . . Industry's Challenge," paper given at Lindbergh Symposium on Environment and Technology, Orlando, FL, February 1986.

[29]Christopher J. Daggett, speech given at New Jersey Institute of Technology symposium, *Waste Reduction: How To Make It Happen*, Mar. 12, 1986.

4. substituting raw materials that introduce fewer hazardous substances or smaller quantities of such substances into the production process; and
5. redesign or reformulation of end products.

These options are given in order of decreasing use as reported by the 99 companies included in OTA's industry survey. Table 2 summarizes an analysis of major published case examples of waste reduction in terms of the distribution of these five approaches over industrial categories (also included is a class that includes measures deemed waste management by OTA). The pattern of usage is the same as that derived from the survey. In-process recycling is the method closest to pollution control, which may make it the easiest option to recognize and implement. But there are important limits to recycling, mostly of an economic nature. Moreover, many times there are other waste reduction measures possible that offer greater benefits.

Contrary to what is sometimes said because of concerns about product quality, improvements in process technology and equipment appear to be a practical means to waste reduction. Such improvements are very important because often an entire waste stream can be eliminated. The literature of case studies and examples of successful waste reduction reveal that, contrary to what is often assumed, this approach is often possible without significant capital investment. As waste reduction is increasingly pursued by a generator this may change, but most U.S. efforts have not yet reached that point. The usefulness of this method depends, however, on the type of industry. Mature industries that use continuous processes are likely to have few opportunities for changes in process technology, but they may still have waste reduction opportunities in the other categories. Box E illustrates one possible means of reducing hazardous wastewater from the manufacture of acrylonitrile by changing process technology. In terms of weight, all hazardous wastewaters constitute the single largest kind of hazardous waste.

Improvements in plant operations can be accomplished by every waste generator, typically with little testing or capital investment. Opportunities for raw material changes may not be present everywhere, but substantial waste reduction has been accomplished this way. Clearly, end product changes by a waste generator are the most difficult to accomplish. This is probably the only one of the five classes for which there is not evidence of significant generic waste reduction opportunities.

Generic opportunities are based on commonly used processes or materials and thus are the major means of promoting waste reduction through intensive information transfer and technical assistance. Examples include: replacement of organic solvent raw materials with water-based ones, in-plant recycling of organic solvents, changes in process technology and operations to reduce hazardous wastewater generation, and changing material removal techniques from chemical to mechanical systems.

Table 2.—Industry Use of Waste Reduction Methods

SICs	Industry	Waste reduction methods						
		In-process recycling	Plant operations	Process technology and equipment	Process inputs	End products	Waste management	Totals
10	Metal mining	—	—	—	—	—	1	1
14	Nonmetallic mining except fuel	1	—	—	—	—	—	1
16	Heavy construction	—	—	—	1	—	—	1
20	Food and food processing	6	—	2	—	—	5	13
22	Textile mill produces	6	—	4	1	—	1	12
24	Lumber and wood products	5	—	—	—	—	—	5
26	Paper and allied products	5	1	4	2	—	1	13
27	Printing and publishing	3	—	—	1	—	1	5
28	Chemicals and allied products	30	16	37	6	2	14	105
29	Petroleum and coal products	3	—	1	—		1	5
31	Leather and leather products	3	—	3	1	—		7
32	Stone, clay, and glass products	4	—	8	—	—	—	12
33	Primary metal industries	12	—	11	—	—	7	30
34	Fabricated metal products	23	7	14	5	1	8	58
35	Machinery, except electrical	1	3	4	—	—	4	12
36	Electrical and electronic equipment	4	—	2	1	—	2	9
37	Transportation equipment	1	—	5	1	—	—	7
38	Instruments and related products	1	2	—	—	—	1	4
39	Miscellaneous manufacturing industries	2	—	—	—	—	—	2
49	Electric, gas, and sanitary services	—	1	—	—	—	10	11
76	Miscellaneous repair services	—	—	1	—	—	—	1
	Totals	110	30	96	19	3	56	314

SOURCE: Office of Technology Assessment, compiled from: D. Huisingh, et al., *Proven Profits From Pollution Prevention* (Washington, DC: The Institute for Local Self-Reliance, 1985); *Compendium on Low and Non-waste Technologies* (Geneva, Switzerland: United Nations Economic Commission for Europe, 1981-84), four vols.; M. Overcash, *Techniques for Industrial Pollution Prevention* (Chelsea, MI: Lewis Publishers, Inc., 1986). Originally assembled and developed as *Les Techniques Propres dans l'Industrie Francaise* (Paris: The Ministre Du L'Environnement, 1982); U.S. Department of Defense, Environmental Leadership Project, *Industrial Processes To Reduce Generation of Hazardous Waste at DOD Facilities*, Phase 2 Report: Evaluation of 18 Case Studies, prepared by CH2M Hill (T. Higgins), July 1985; D. Sarokin, et al., *Cutting Chemical Wastes* (New York: INFORM, 1985); and Federal Minister for Research and Technology (DFVLR), *Environmental Protection Technologies* (Cologne, West Germany: DFVLR, December 1984). (Note that this last volume documents ongoing research rather than industrial application of technologies.)

Box E.—Possible Process Technology Change for Reduction of Hazardous Wastewater From Manufacture of Acrylonitrile

In 1985 acrylonitrile ranked 38th in the list of the top 50 chemicals made in the United States, ranked 19th out of the 26 organics on the list, and had the highest annual growth rate of the organics during 1975 to 1985 with an average of 6.8 percent. Production in 1985 was 2.35 billion pounds (1.1 million metric tons).[1]

For each metric ton of acrylonitrile product manufactured, 400 metric tons of cooling water are used.[2] For every gallon of cooling tower water circulated, a small fraction called blowdown is discarded to remove the buildup of slime and solids which accumulate during recirculation. This blowdown contains toxic chemicals used as bactericides and fungicides and is a hazardous waste. A typical blowdown ratio is about 0.5 percent of the circulation rate. For the 400 metric tons of cooling water used per ton of product, 2 metric tons of wastewater are generated. About 2.2 million metric tons of cooling wastewater is generated annually.

A closed-loop coolant refrigeration system could be used in place of cooling with water. After the coolant was used to cool the process, it would be compressed to a higher temperature and pressure and then passed through a radiator that would reject the heat to the environment. The operating costs for cooling are from $0.02 to $0.07 per hour per ton of product.[3] The costs for managing the traditional cooling wastewater, if the injection well costs are from $0.05 to $0.10 per gallon, are $0.03 to $0.06 per hour per ton of product.

There is a clear potential for saving perhaps $20 per ton of product if closed-loop, efficient refrigeration is used instead of conventional water cooling. For a 100,000 ton per year plant this means a saving of about $2 million annually. Assuming that the capital costs of the refrigeration system might be $50 million (at most about 10 percent of the original capital costs of the plant), then payback would occur in a few years.

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[1]*Chemical & Engineering News*, Apr. 21, 1986.

[2]*Hydrocarbon Processing*, May 1977, p. 171. The data are based on the Monsadison-UCF process which differs from the more widely used SOHIO process primarily because of a different catalyst. However, similar water use and wastewater generation can be assumed for both.

[3]The operating costs of this refrigeration cycle can be estimated making the following assumptions: 1) 12,000 Btu per hour per ton of cooling requires 120 gallons per hour of cooling water for a 12° F rise, 2) coefficient of performance ranges from 2 to 7, and 3) energy costs are $0.04 per kilowatt-hour.

From the perspective of the plant operator, waste reduction efforts that require significant capital and human resources will always face competition from expenditures related to pollution control requirements and from traditional corporate uses of resources to maintain or improve competitiveness and profitability. Thus, it becomes important to understand that *there is a spectrum of technical means to carry out waste reduction and these vary greatly in technical complexity, cost, and effectiveness*. Not all plant personnel will necessarily have the technical ability or motivation to examine all waste reduction options or to carry

them out. Nor should it be assumed that plant personnel are aware of the benefits or need for reducing waste. Senior management must give priority to waste reduction, but this is far from the only requirement.

SUMMARY ISSUE 6:
If waste reduction is so site-specific, would Federal initiatives pose risks and problems for U.S. industry?

OTA Finding:

There are well-founded technical and economic reasons for industry, particularly troubled manufacturing sectors, to have concerns about government initiatives that might be inflexible. Some initiatives might not be sensitive to alternatives to waste reduction and the limited capabilities of some companies or plants within companies to reduce waste. On the other hand, Federal actions would have to exert enough pressure on waste generators to bring about serious evaluations of the technical and economic aspects of waste reduction opportunities at their sites.

Discussion

It is difficult to generalize—strictly from a waste reduction standpoint—about what can be done technically within a specific plant operation at a particular time. Equipment, physical layout, control instrumentation, raw materials, product specifications, and volume of output may vary significantly from plant to plant, even for plants making the same product. All of these and probably other factors will affect the applicability and difficulty of any waste reduction approach. Different amounts of R&D, testing, capital investment, and time may be required for different plants. The effectiveness of a given approach to waste reduction will vary among plants, although they use the same process technology or produce the same product. In one operation a given approach may eliminate an entire waste stream; in another operation it might not.

Many large companies that are able to manage their hazardous wastes onsite prefer waste treatment to waste reduction, particularly if they are treating wastes rather than using land disposal. From such an industrial perspective, environmental protection is served by pollution control and waste management methods that are *allowable under the law* and that reduce the use of land disposal. Indeed, many in industry believe that waste treatment is just as valuable a means of achieving pollution prevention as is waste reduction. (On the basis of the thermodynamic principle of steady entropy increase, however, it is more efficient to prevent pollution before waste is created and given a chance to disperse.) Capital and technical requirements for waste reduction may be rejected because so much investment has been made for pollution control. For all these reasons, the flexibility of Federal initiatives is of concern to industry.

It is also difficult to generalize about methods that will be cost-effective, economically feasible, or profitable at a particular site. In general, making quantitative estimates regarding waste reduction is difficult. There are many factors on the cost and benefit sides of the equation that are bound to vary substantially from one generator or waste to another (see box F). Yet being able to predict the *economic* feasibility or practicality of an action at a specific industrial site is critical to those who are about to take action to reduce waste. A great deal depends on the economic circumstances and internal evaluation criteria of a company or a specific plant. Not all companies will apply strict financial criteria, such as a minimum return on investment, in order to carry out waste reduction, but some will. For some, only the more immediate costs and benefits of waste reduction seem important, but other companies factor in uncertain, potentially large long-term liabilities of pollution control. There are also many potential but uncertain benefits that may come from waste reduction. Taking waste reduction seriously may trigger substantial, innovative changes in manufacturing technology. **A new focus on waste reduction offers an opportunity to reappraise and modernize plant process technology**. All too often economic factors are used prematurely to dismiss serious consideration of waste reduction. Thus, while government actions need to be flexible, they also need to exert enough pressure on waste generators to ensure that they take action to evaluate thoroughly the technical and economic aspects of waste reduction measures.

The site-specific character of waste reduction also raises the issue of possible negative effects of government initiatives that might not be sufficiently flexible. For example, the more mature an industrial technology in a plant and the older the plant is, the more costly any but the simplest forms of waste reduction are likely to be. It is often very difficult for existing industrial operations to make capital-intensive changes in basic technology and processes for waste reduction; the situation can be entirely different when new operations are being designed. However, as noted earlier, considerable waste reduction is being accomplished without significant capital investment.

Many American manufacturing industries are having major competitive problems marked by plant closings, employment cutbacks, and loss of market share to imports. These industries may face major financial and human resource limitations to waste reduction. **A shift away from a voluntary waste reduction approach is likely to be viewed apprehensively by troubled industries, which already cite the heavy costs of coping with existing pollution control programs. Also, areas with high and persistent unemployment are likely to worry about anything that could further burden their surviving industries. For such companies, assistance and regulatory flexibility may be key.**

Box F.—Problems in Assessing the Costs and Benefits of Waste Reduction

Costs Will Vary

Information.—It is often necessary to spend money on a waste reduction audit, for example, to get detailed information about wastes. These costs can be high for operations that generate many different kinds of waste from a multitude of processes and for firms that change their product mix frequently. For smaller firms with fewer resources these costs may be a significant obstacle. Although an audit may be avoided at the simplest stages of waste reduction, as more complex waste reduction is pursued, it will likely have to be done. It is also necessary to spend money to get information about waste reduction methods.

Testing and R&D.—Sometimes testing and even formal R&D are necessary to: 1) assess the technical and economic feasibility of specific waste reduction measures, and 2) identify risks to product quality posed by some waste reduction measures. These costs are likely to grow as a waste generator moves toward more complex methods to reduce waste.

Capital Investment.—Implementation often involves virtually no capital, but sometimes—and perhaps increasingly so as waste reduction is pursued—significant capital investment may be necessary.

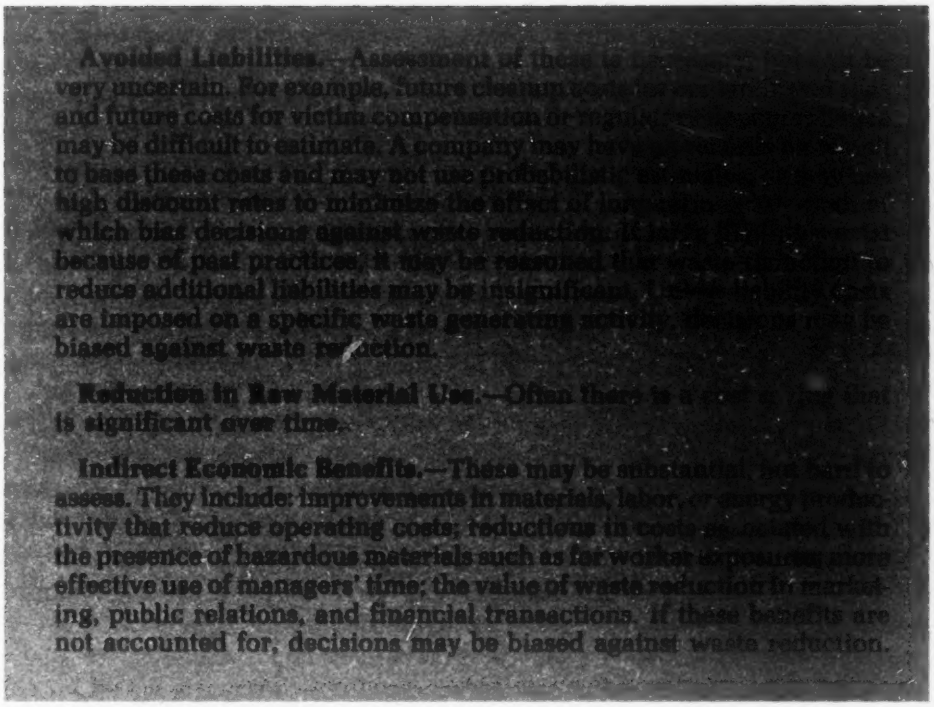
Operations and Production.—Implementation may involve some operating and maintenance costs that should not be ignored.

Training.—Spending on training for workers may be required so that they can implement and work effectively with new waste reducing processes.

Management.—Identification of waste reduction opportunities and effective implementation may require spending on management systems, including better accounting of costs, measurement of waste reduction, and administering reward and incentive programs for workers.

Benefits Are Often Uncertain

Avoided Waste Management.—Savings of all sorts must be assessed, including: 1) direct savings on handling, storage, transport, and treatment or disposal (even if wastes are managed onsite); and 2) indirect savings on the costs of regulatory compliance, legal advice, insurance, and managerial time. Basing estimates of direct savings on current costs may be misleading because waste management costs continue to rise substantially. Estimates of both direct and indirect savings may also be difficult to make because they require anticipating future regulatory actions and their effect on waste management costs and practices. Accounting systems that do not impose waste management costs on specific waste generating activities bias decisions against waste reduction.



Avoided Liabilities.—Assessment of these is very uncertain. For example, future cleanup costs and future costs for victim compensation or regulation may be difficult to estimate. A company may have to base these costs and may not use probabilistic high discount rates to minimize the effect of which bias decisions against waste reduction. because of past practices, it may be reasoned reduce additional liabilities may be insignificant are imposed on a specific waste generating biased against waste reduction.

Reduction in Raw Material Use.—Often there is is significant over time.

Indirect Economic Benefits.—These may be substantial but hard to assess. They include: improvements in materials, labor, or energy productivity that reduce operating costs; reductions in costs associated with the presence of hazardous materials such as for worker or property more effective use of managers' time; the value of waste reduction in marketing, public relations, and financial transactions. If these benefits are not accounted for, decisions may be biased against waste reduction.

SUMMARY ISSUE 7:
Should the Federal Government move from a mostly voluntary approach to waste reduction to a more prescriptive approach?

OTA Finding:

A choice cannot be made between a voluntary and a prescriptive approach on the basis of good, quantitative data because such data do not exist. Moreover, there are other, less extreme, options open to government that might be effective, such as persuasion, assistance, offering incentives, and providing information. Qualitatively, it is possible to conclude that action short of a prescriptive approach could markedly increase the pace and scope of waste reduction. OTA has reached this conclusion based on the following:

- the government has done little to draw attention to waste reduction but has imposed substantial regulatory requirements for pollution control which themselves limit resources for waste reduction,
- there is no generally accepted definition of waste reduction that clearly distinguishes it from waste management,
- there is no standard way to measure waste reduction, and
- there is no consensus or policy that articulates the position that waste reduction should apply to all regulated and unregulated hazardous waste and all environmental media.

Discussion

There is a fundamental antipathy in industry toward government involvement in the front end of production, where waste reduction must take place, and there is a strong belief that the voluntary approach to waste reduction is the proper one. However, any waste management facility—onsite as well as commercial, treatment as well as disposal—poses environmental risks and requires effective government regulation and enforcement. Therefore, some believe that government ought to *require* waste reduction just as it *requires* pollution control measures.

As long as waste reduction is a voluntary effort by industry, the site-specific character of waste reduction can be handled by the individual waste generator. But if government were to *require* waste reduction, it would face major difficulties in determining what is technically and economically feasible or practical for a specific industrial operation. Hence, the wisdom of involving government in production is a critical issue, made all the more difficult to resolve by the substantial uncertainty about how much waste reduction is possible or feasible for industry in general and for specific operations in particular. There is also some uncertainty about how willing industry is to examine and use the full range of options available to implement waste reduction. As a spokesman from the Chrysler Corp. said:

> . . . the economics that have prevailed considered only the 'front door' costs without regard to 'back door' costs. These factors . . . have not caused a sufficient concern to drive new technology with the overall cost viewpoint to product in and waste out.[30]

Whether it be for environmental or economic reasons, does waste reduction have primacy in most of U.S. industry? A recent study asked a similar question and concluded:

> The present status (1982-86) is that a major effort in waste minimization [waste reduction as defined here and offsite recycling], across diverse categories of industry has not been undertaken.[31]

Many in industry want to reduce wastes, but do not know how to start or do not know how to move beyond the simplest measures. Others believe that they have accomplished all the waste reduction that they can and that if more opportunities present themselves they will respond in any way that is feasible. But it is not clear what definition they are using for waste reduction; whether they are talking about not generating waste to begin with or whether they are talking simply about avoiding land disposal. It is also not clear whether they are considering the reduction of all hazardous wastes or only those regulated under RCRA. **Often industry sees waste reduction as something that must take its own course, that will be accomplished when its time arrives. This attitude alone is a large barrier to waste reduction.**

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[30] *Waste Reduction—The Untold Story*, proceedings of a League of Women Voters conference, Woods Hole, MA, June 1985.

[31] Michael R. Overcash, *Techniques for Industrial Pollution Prevention* (Chelsea, MI: Lewis Publishers, Inc., 1986).

Too often, the bare suggestion of Federal action to directly promote more waste reduction, is interpreted as advocating waste reduction by regulation. But OTA finds that the design, implementation, and enforcement of a prescriptive regulatory approach are not technically feasible because of the multitude of diverse, often site-specific waste generating processes. (A number of other options for Federal action that could be effective are discussed in chapter 2 of the full report.)

SUMMARY ISSUE 8:
Does the existence of State programs remove the need for Federal initiatives? Do State programs offer clues for Federal initiatives?

OTA Finding:

Current State programs are not substantially increasing waste reduction nationwide. States are primarily concerned with avoiding land disposal and, as a result, State programs promote preferred waste management more than waste reduction. States have found it practical to take a nonregulatory approach to promote waste reduction. Because of low funding and limited staffing, few attempts have been or will be made to measure the effectiveness of State programs. Although States have led the Federal Government in actively promoting waste reduction, a parallel Federal effort is needed to raise waste reduction to a stature comparable to that of pollution control.

Discussion

A small number of States have shown considerable initiative and leadership in moving into waste reduction.[32] Those in State programs are enthusiastic but resources are limited (to no more than 1 percent of overall environmental protection spending). **State programs often deal primarily with waste *management*, not the reduction of waste at its source, even though the term *waste reduction* may be used.** States have not given much attention to non-RCRA wastes and multimedia issues in their programs, and they tend to concentrate on the waste problems of small business.

OTA finds that 10 States have waste reduction programs in place that: 1) establish an organization responsible for promoting waste reduction, and 2) have moved beyond planning to implemetation of their waste reduction program (see table 3 and ch. 6 of the full report). The North Carolina program (see box G) is the most comprehensive and the most focused on waste reduction. It is unique among State programs because of its multimedia perspective.

[32]This report has not attempted to examine the role of local governments. Many actions which States or the Federal Government might take could also be—and in a few cases have been—applied at the local level. For example, waste reduction plans and goals can be required for local land use permits. See Susan Sherry, et al., *High Tech and Toxics: A Guide for Local Communities* (Washington, DC: Conference on Alternative State and Local Policies, 1985).

Table 3.—State Programs With Waste Reduction Activities

State: Program name and/or coordinating body	Program components	Annual budget[a]	Waste reduction as percent of activities	Notes
California:				
Waste Reduction Unit (Alternative Technology & Policy Development Section of Department of Health Services)	Research grants Technical assistance	$1.5 million	<25	$1 million of funds used for grants
Connecticut:				
Office of Small Business Services (Department of Economic Development)	Technical assistance Loans	$50,000	<10	Lost $10,000 in funding for 1986-87
Georgia:				
Hazardous Waste On-Site Consultation Program (Georgia Tech Research Institute)	Technical assistance	$220,000[b]	10-15	Primarily compliance assistance to SQGs
Illinois:				
Hazardous Waste Research & Information Center	Research Technical assistance	$1.3 million	10	Most of funds for research on hazardous waste problems
Minnesota:				
Minnesota Waste Management Board	MnTAP Research grants Governor's Award	$235,000	25	Also has summer engineering student intern program
New York:				
Industrial Materials Recycling Act Program (NY State Environmental Facilities Agency)	Technical assistance Industrial financing	$494,000	<25	—

Table 3.—State Programs With Waste Reduction Activities—Continued

State: Program name and/or coordinating body	Program components	Annual budget[a]	Waste reduction as percent of activities	Notes
North Carolina:				
Pollution Prevention Pays	Technical assistance Challenge grants	$590,000[b]	>50	Multimedia focus
North Carolina Board of Science and Technology	Research and Education grants			
Governor's Waste Management Board	Governor's Award			
North Carolina Technical Development Authority	Financial assistance			
Pennsylvania:				
PennTAB (operated by Penn State University; funded by Department of Commerce)	Technical assistance	$150,000[c]	<50	2 of 12 staff handle environmental assistance
Tennessee:				
Safe Growth Cabinet Council	Governor's Award	$1.8 million[b]	>25	$1.7 million of funds for University of Tennessee research program
Department of Economic and Community Development	Technical assistance			
Center for Industrial Service (University of Tennessee)	Hazardous Waste Extension Service			
Waste Management, Research & Education Institute (University of Tennessee)	Engineering research and development, policy research			
Wisconsin:				
Bureau of Solid Waste	Information outreach Research grants Tax exemptions	$850,000	<25	Only about $150,000 will be available in fiscal 1986-87

[a]1985-86 unless otherwise indicated.
[b]EPA source of some/all funds.
[c]Estimate, based on staffing level for environmental assistance.

SOURCE: Office of Technology Assessment, 1986.

Box G.—The North Carolina State Program

North Carolina's Pollution Prevention Pays Program is unique in that *it is a multimedia program. It focusses largely, but not exclusively, on waste reduction.* The program's current annual budget totals $500,000 and contains both State and Federal funds.

The original idea for the program in North Carolina came from local environmentalists and was proposed as an alternative to land disposal of hazardous wastes. A number of State officials who recognized the need for a multimedia approach then played key roles in the development of the program and the building of consensus among members of the State legislature, State regulatory officials, industry, and other environmentalists.

Despite wide support for the program, expansion of its role in the near future is constrained by overall budget concerns of the State. Any budget increases that are available for environmental issues will go to the regulatory programs. The program considers an increase in its technical assistance staff—to allow for more onsite consultations—its most critical need.

So far, the program has documented the number of firms it has assisted and the types of projects that have ensued. It has developed one of the largest libraries and published the best bibliography on waste reduction and recycling. It is not known yet, however, whether the program's activities have contributed to a reduced need for land disposal facilities or improved the environmental condition of the State.

Technical Assistance.—In its first year of operation in 1985, technical assistance was conducted primarily by dealing with telephone calls. Five onsite visits were managed in the last half of 1985, and the program hopes to average one a month in 1986. An information clearinghouse has been developed that includes the capability to conduct data searches through a variety of databanks. An in-house database is now being developed that will include literature, case studies, contacts, and program publications. Outreach consists of presentations by the program staff to a wide variety of organizations.

Research and Education.—Through Research and Education Grants, the program promotes research projects and develops educational tools. Research grants were first awarded to 13 university projects in 1984. A third round of 11 awards were made in 1986. Of these 11 projects, 10 deal with waste reduction.

Financial Assistance.—The program's ability to provide financial assistance comes primarily from the Challenge Grants. They are given to small businesses and communities for the development and implementation of waste reduction and recycling projects that are transferable to other firms or communities in North Carolina. Funding totals about $100,000 each year and is provided by the State and by EPA grant. The maximum for a Challenge Grant award is $5,000, and the average awarded must be matched by the recipient. Seven projects were awarded in 1985 and 13 in 1986. Of the recent group, nine are waste reduction projects.

Understandably, States pay most attention to local concerns and, therefore, to actions aimed at 1) discouraging or minimizing land disposal of hazardous waste, a major public issue at the State level; and 2) encouraging the use of waste exchanges and offsite waste recycling as positive alternatives to land disposal, particularly for smaller companies. Waste reduction is not always perceived as a viable alternative for small businesses or as an immediate solution to a pressing issue.

The land disposal of hazardous wastes is an example of a pollution control method that has often failed in the past. States have been spending considerable resources to resolve this emotional, politically charged issue. One recent publication for State officials cautioned:

> Any state legislator must realize, however, that whether or not the sites are developed, the waste *will* be disposed of—legally or otherwise.[33]

No consideration was given in that report to the potential contribution waste reduction might make towards solving this problem.[34] Waste reduction is often viewed as less important and urgent than siting and as representing a diversion of resources. The uncertainty that waste reduction introduces can cloud the market's need for new waste management facilities. **But, waste reduction can be viewed as a *means of alleviating the need* for siting waste management facilities and for *assuring the public that only truly necessary facilities will be sited.*** There are indications that some siting programs are now taking a positive view of waste reduction rather than seeing it as a threat. Overall, the pressure associated with siting difficulties has probably played a positive, indirect role in stimulating interest in waste reduction by industry and the public.

Most States promote waste reduction by focusing on information transfer and technical assistance. Most activity is directed at small businesses although they may be responsible for only a fraction of hazardous wastes generated. Few attempts have been made or systems developed to document the effects State programs have had on waste reduction. This lack of attention to measuring effectiveness is understandable, given the recent startup of programs and their limited resources. Moreover, State programs are but one of a number of factors affecting waste reduction plans and actions. In OTA's survey of industry about 10 percent overall (about 17 percent for small companies and 6 percent for large firms) indicated that State programs had affected their waste reduction efforts.

The limited promotion of waste reduction at the State level reflects constraints on waste reduction nationwide. Clearly there is no broad consensus yet at either the State or Federal level on the primacy and near-term feasibility of waste reduction. Waste reduction is not yet per-

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[33]J. Ward Wright, *Managing Hazardous Wastes*, The Council of State Governments, 1986, p. 61.

[34]Waste reduction is not singled out for attention in the National Governor's Association, "Policy Positions 1985-86." One component of waste reduction is briefly acknowledged within the policy section on siting: "*[s]ubstitution of nonhazardous chemicals*, incineration, and new treatment technologies can all contribute to decreasing the need for disposal capacity" [emphasis added].

ceived as being on a par with or as necessary as existing regulatory programs. **Those administering pollution control programs often feel uneasy about the prospect of government shifting priority and resources to waste reduction. Waste reduction is viewed by some as anti-business, chiefly because of its perceived potential for thwarting waste management siting attempts or leading to burdensome regulations.** These problems result from the fact that most people see waste reduction solely as an alternative environmental solution and not as a broadly applicable means of improving industrial efficiency and encouraging industrial growth. So far, few people view waste reduction as contributing to safe and publicly acceptable industrial development. Many more people may do so as the economic and industrial benefits of waste reduction become better understood.

POLICY OPTIONS

The major obstacles to increased waste reduction are institutional and behaviorial rather than technical. Economic considerations are not an intrinsic impediment to waste reduction; rather, there are hurdles or barriers to overcome before short- and long-term economic benefits can be realized by waste generators. For example, 3M has concluded:

> The initial investment for a pollution prevention project may be higher in some cases than the cost of installing conventional pollution removal equipment. However, the annual operating and maintenance cost of the removal equipment will almost always make the total cost of this technology higher than the total cost of preventing pollution at the source.[35]

This does not mean that all waste reduction measures are economically equal. On the contrary, as a waste generator increasingly implements waste reduction and moves away from simple approaches, capital costs and the uncertainty about effectiveness may increase. Some government policies, therefore, will be more effective for generators who are just beginning to reduce waste, while others are more important for sustaining long-term waste reduction.

Of paramount importance is how people and organizations perceive the need for waste reduction, how they evaluate a full range of methods for its implementation, how they make a decision to proceed, and how they are rewarded. Considering that there has been no major public debate on Federal waste reduction policy, it is not surprising that there is not yet a consensus on what the congressional role might be in stimulating greater levels of waste reduction.

There are significant, broadly perceived problems with the current pollution control regulatory program, and remedies to improve environmental protection are often directed toward making the regulatory program more effective. Developing more comprehensive regulations

[35]M.D. Koenigsberger, paper presented at the Governor's Conference on Pollution Prevention Pays, Nashville, TN, March 1986.

or instituting stronger enforcement are the most commonly voiced suggestions, and both are sound approaches. **But the current regulatory system can be strengthened *and* waste reduction can be pursued.** The choice should not be seen as one between pollution control and waste reduction. For those who see a hazardous waste crisis as a major environmental issue,[36] waste reduction is increasingly accepted to be the most important part of the solution. But effective pollution control regulations will always be necessary.

Almost all of the Federal environmental statutes have offered some opportunities to pursue a waste reduction strategy (see ch. 5 of the full report), but these opportunities have not often been taken. No environmental protection strategy based on pollution prevention has been developed within the larger pollution control framework. Pollution control continues to be the attractive route because people in industry and the regulatory agencies believe that end-of-pipe techniques are easier and more practical to apply than waste reduction, and when pollution problems were first identified this was probably the case. Now, however, prevention is more effective than control.

There are many opinions voiced about waste reduction, but one fact is incontrovertible: public policy on the issue, which is in its earliest—and perhaps most critical—stage of development, cannot rest for reinforcement on a body of detailed information. Straightforward big picture questions about waste reduction cannot at this time be answered quantitatively or even semiquantitatively. Answers to questions such as "How much waste reduction has industry accomplished on its own?" can now only be answered with subjective impressions or with examples that sound significant but may be atypical. **There is more talk about waste reduction by those who are not responsible for implementation than there is by those in industry, and industry people should be the source of detailed information. However, the lack of detailed information does not prevent our drawing certain important conclusions on the basis of logic, common sense, and qualitative information.**

It is also difficult to evaluate the costs of certain types of policy actions because of the virtually innumerable technical ways to reduce waste. For example, direct economic incentives or financial assistance, if offered, might be used by nearly all industries for a host of actions despite the fact that these actions vary remarkably in their waste reduction intensity. It is not obvious what criteria could be used to limit access to direct government assistance, and some limitations would have to be set, as for any Federal financial support program.

Relatively low cost, unintrusive government actions based on persuasion, assistance, incentives, and education seem the best route to pursue at this time. Both State and foreign waste reduction programs appear to have adopted this middle course between a totally voluntary approach

[36]Public opinion polls have consistently revealed very strong and widespread concerns about hazardous waste. For example, in May 1986, the Harris Poll announced that 92 percent of the American public consider hazardous waste disposal a serious concern.

and a prescriptive regulatory one. Considering the limited Federal leadership to date, it can be argued that almost anything the government does to foster waste reduction should be viewed as potentially effective. Certain kinds of Federal actions, however, that require large spending or put industry at risk may have difficulty receiving broad support *at this time*. All this may change, however. **If an informed public, greatly concerned about hazardous waste, becomes convinced that industry is lagging in reducing waste, then it will call for more prescriptive and costly Federal initiatives.**

OTA has not examined all possible policy options. Three major options have been formulated and are briefly summarized below. (Detailed policy analysis appears in chapter 2 of the full report.) Some actions from each option might be combined as they are not necessarily mutually exclusive. The choice of the three strategically different options has been made to clarify for Congress the range of distinctly different choices that can be considered. **Regardless of what course Congress pursues, waste reduction *must* be unambiguously defined so that industrial efforts are channeled away from traditional waste management to true waste reduction.**

Policy Option I: Maintain Current, Limited Voluntary Program

Under this option, no new Federal waste reduction initiative would be taken, with the exception of making some effort to obtain reliable information on the current extent and pace of waste reduction. For the most part, this option is a market driven approach. The premise is that what the Federal Government is now doing is sufficient to allow the marketplace to operate efficiently. Primarily, this means letting the indirect economic incentive of the pollution control regulatory system function.

This option is not a true no action option because it requires strong congressional oversight of existing environmental programs. It is undisputed that a well-enforced pollution control regulatory system acts as an important incentive for some waste reduction efforts when waste reduction is chiefly a voluntary effort by industry. Moreover, congressional oversight—if linked to waste reduction—could catalyze widespread public scrutiny and lobbying that might make the marketplace move vigorously toward waste reduction. (The public can play this role, of course, with either of the other two options as well.) Another limited action by Congress or EPA that would be necessary for this option is collecting reliable, systematic data on the extent of waste reduction that is now taking place nationwide. Consistent with the basic character of this option, however, information gathering would be achieved through a study rather than through comprehensive collection of data from all or most waste generators.

The chief advantage of this option is that it imposes no new major costs on government or industry. Harmful impacts on troubled industries are not likely to occur as companies would decide individually what waste reduction methods to implement. Its chief weakness is that

relying on the indirect incentive of rising waste management and regulatory compliance costs can be ineffective. Companies may not have the technical and economic resources to respond to the incentive, and if they do respond it may not be with waste reduction efforts. In addition, the incentive may not apply to companies where those costs are small relative to overall production costs. **Various congressional and regulatory actions may reduce or confuse the perceived incentive by, for example, promoting pollution control rather than waste reduction.** In general, gauging the likelihood that the marketplace will respond to indirect incentives is a complex matter. There is substantial inertia in the existing system. In theory the marketplace may be responding, but in practice that response can be slow and uneven. Moreover, this option would not address the deficiencies and limits of the existing national waste reduction effort with regard to multimedia coverage. For example, non-RCRA and unregulated hazardous wastes may not receive major attention by waste generators, who are accustomed to defining hazardous wastes only as the government has defined them under RCRA.

This option is attractive to those who want to maintain the voluntary approach to waste reduction and initiate the least possible amount of government activity until there is more evidence of insufficient waste reduction.

Policy Option II: Change and Expand Existing Programs

A number of actions are possible that could affect, either directly or indirectly, the extent and pace of waste reduction in industry. **The actions included in this option can build on existing, familiar government programs and policy approaches.** Most of what the government now does relative to hazardous waste falls under the stick rather than carrot approach; the following possible actions reflect this choice:

1. modify and strengthen the existing RCRA waste minimization reporting and planning requirements,
2. adopt similar reporting and planning requirements for the other major environmental programs,
3. use waste reduction impact analysis for regulatory actions,
4. initiate a periodic chemical survey of industry,
5. mandate amounts of waste reduction in wastes and processes to be achieved by industry,
6. tax all wastes and possibly offer rebates for those who have reduced wastes substantially or who will do so,
7. establish a waste reduction R&D program in EPA, and
8. change government procurement policies to facilitate waste reduction.

The chief strength of this option is that it would provide strong government action that would shift waste reduction from a voluntary effort to something closer to what now exists for pollution control. Its chief weakness is that, based on historical experience, it is likely to be

ineffective in achieving rapid and comprehensive waste reduction by using the existing, predominantly pollution control system. Also, harmful economic impacts on U.S. industries might result from overly burdensome or inflexible requirements.

This option is most attractive to those who want to move faster with government requirements for waste reduction than the voluntary approach permits, but who want to do so without establishing major new programs.

Policy Option III: A New Highly Visible Waste Reduction Program

The fundamental criterion for this option is the primacy of waste reduction (as defined in this report) over pollution control. Exercising this option would be tantamount to establishing a new waste reduction ethic for American society. Another premise of this option is that existing environmental statutes and programs will not do the job as proven by the unsuccessful attempts to include pollution prevention in pollution control programs. This option emphasizes Federal assistance and direct incentives to *spur* rather than *require* more waste reduction. But certain Federal requirements would necessarily be placed on generators. **The goal would be to elevate waste reduction to a level comparable to that of pollution control.** While few new responsibilities would be added to existing EPA programs, several new programs would be created to give unambiguous and unequivocal Federal support and commitment to the primacy of waste reduction over waste management. Possible actions under this option are:

1. establish a grants program to fund a variety of activities that support industrial waste reduction, such as technical assistance and generic R&D (funding would not be available for specific waste reduction efforts by individual companies);
2. enact new waste reduction legislation based on the multimedia concept, with expanded Federal reporting and planning requirements for industry;
3. establish reporting requirements on waste reduction for financial reports to the Securities and Exchange Commission;
4. create a new EPA Office of Waste Reduction with an Assistant Administrator;
5. allow regulatory concessions, i.e., trading off certain limited pollution control regulatory requirements for waste reduction achievements; and
6. create independent State Waste Reduction Boards to implement many of the new Federal initiatives.

The chief strength of this option is that it would stimulate and assist rapid, multimedia, comprehensive waste reduction. This option depends on Federal leadership in the forms of institutional attention, assistance, and educational efforts, rather than on regulatory requirements. Its major disadvantage is that more institutional change would be necessary, and this raises problems about implementation.

This option is most attractive to those who want to see waste reduction given strong Federal support and a very high priority—and who also would like to see Federal policy implemented as much as possible at the State level.

Comparison of Policy Options

There is a need to clarify national policy on waste reduction, including the matter of its primacy over waste treatment and disposal, as part of any congressional debate on various waste reduction policy options. **Attention to the problems of defining and measuring waste reduction is also critically needed, no matter which course Congress pursues. Federal initiatives on waste reduction could, for example, be ineffective if a definition of waste reduction includes waste treatment.**

If the Federal public policy goal is **rapid and comprehensive** hazardous waste reduction, then the option most likely to attain that goal without harm to American industry is Policy Option III. This option strikes a middle course between a voluntary approach with minimal Federal involvement (Policy Option I) and a more rigid, traditional, prescriptive, regulatory one (Policy Option II). Policy Option III explicitly recognizes the significant effects on waste reduction of other public and private efforts (i.e., State and local programs and those of insurance and financial companies and environmental groups).

This conclusion hinges, in part, on the observation that current data inadequacies make it difficult to justify, design, and enforce a more prescriptive Federal approach at this time. Certain actions contained in Policy Option II could be combined with some or all of the actions in Policy Option III without changing the basic character of Policy Option III. These include: waste reduction impact analysis for regulatory actions, a periodic chemical survey of industry, a waste reduction R&D program within EPA, and changing Federal procurement policies to facilitate waste reduction. Even if Policy Option III were implemented, in whole or in part, information eventually obtained might set the stage for later adoption of Policy Option II.

It is not yet clear, however, whether the above goal is the current Federal public policy goal. Other options may therefore merit serious consideration, either now or in the future. **While the current statement of national policy, as given earlier, is an important affirmation of the importance of waste reduction, it does not explicitly address the issue of comprehensiveness (i.e., multimedia coverage). Nor does it address the possibility of Federal activities that could help generators overcome their site-specific impediments to waste reduction. The statement asks for expeditious waste reduction, but it does so from the perspective of the generator within a voluntary system. Consequently, there is a critical need for a full policy debate on waste reduction before specific actions are taken.**

Assessments in Progress as of September 1986

Technology and the American Economic Transition
High-Technology Ceramics and Polymer Composites
Technologies for Prehistoric and Historic Preservation
Magnetic Fusion Research and Development
Competitiveness of Domestic Copper
Technological Risks and Opportunities for Future U.S. Energy Supply and Demand
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(NOTE: For brief descriptions of these studies in progress, see OTA booklet on "Assessment Activities"—available from OTA's Publishing Office, 224-8996.)

NOTE: Copies of the full report "Serious Reduction of Hazardous Waste" can be purchased from the Superintendent of Documents, U.S. Government Printing Office, Washington, DC 20402, GPO stock No. 052-003-01048-8.

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